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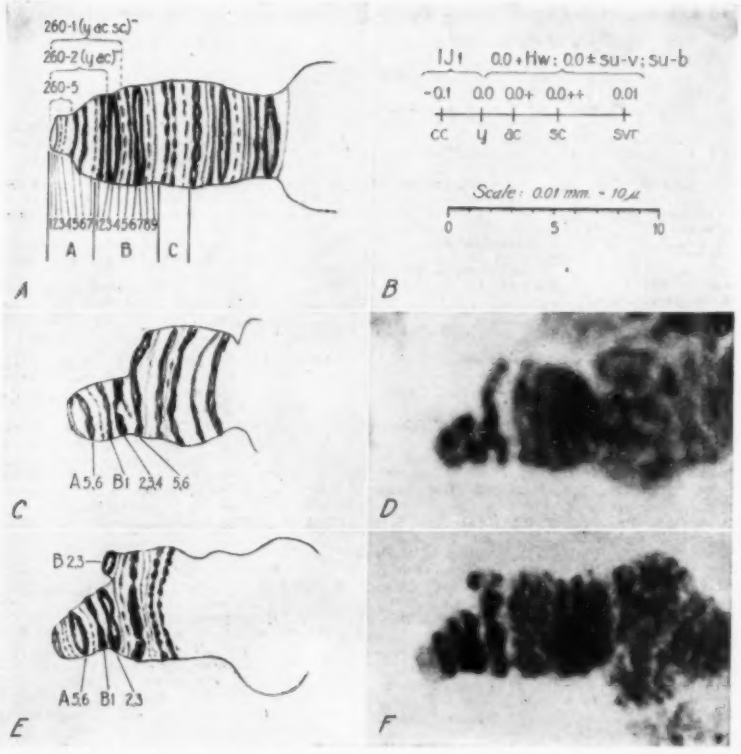

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Preliminary Announcement of Seventh Genetic Congress

VOLUME 27 MAY, 1936 NUMBER 5

The American Genetic Association

An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks

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The

Journal of Heredity

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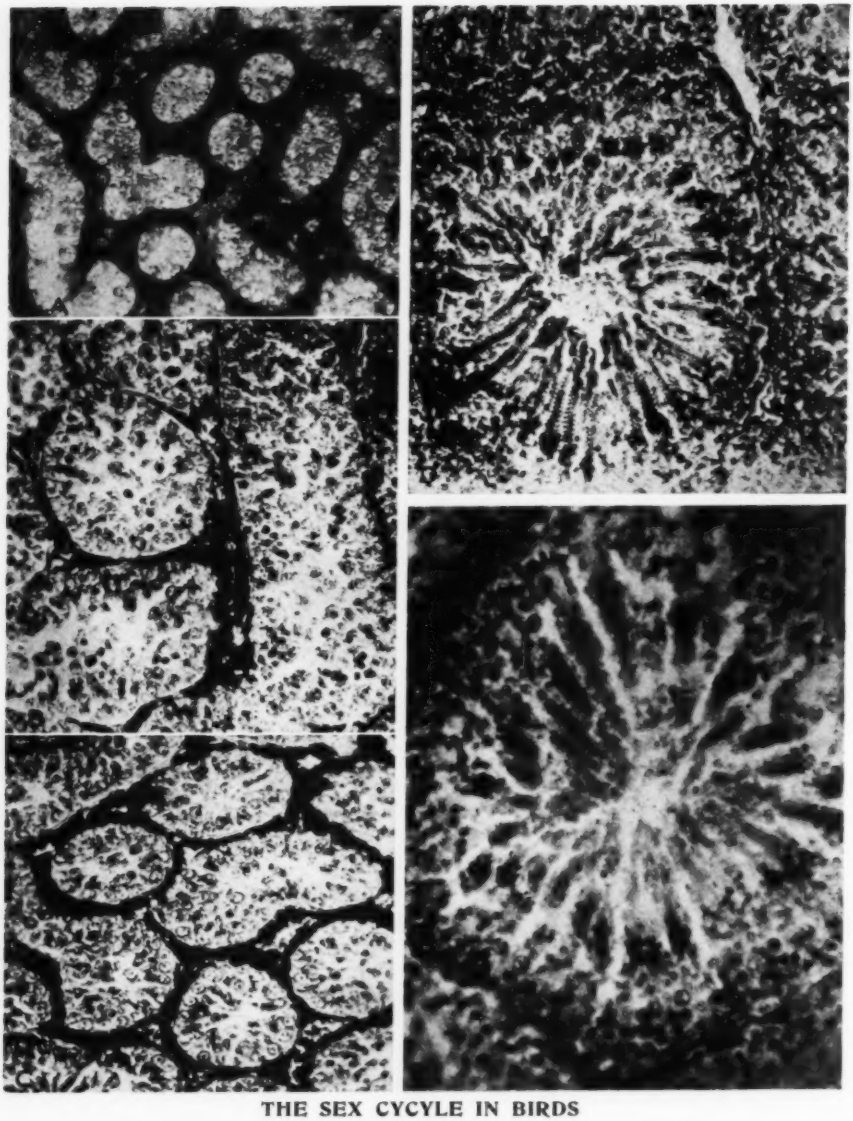


THE SEX CYCYLE IN BIRDS

Frontispiece

The photographs show sections of the testes of male starlings exposed to different light treatments. *A* is a microphotograph (223×) of a section of a testis of a starling taken on November 8, showing the "dormant" condition normal in the fall and winter. *B* shows a comparable section (223×) from a starling captured on March 5. The tubules are beginning to enlarge, and the central canal (leumen) is visible. This is in response to the increasing length of day with the approach of spring. *C* shows a section made on the same day, of the testis of an "inside control" bird given no extra work nor extra light, but confined in the same room with the experimental birds since December 4 *D* shows a comparable section of a testes from a "light treated" bird subjected to about 5-6 hours of extra light each evening from January 15 to March 5. The source of light was a 60 Watt electric bulb. Note the greatly enlarged tubules, active spermatogenesis, and that mature sperms are present. *E* shows a comparable section from the testes of a male starling taken in the wild on April 19.

SEXUAL PHOTOPERIODICITY

Influence of Varying Quantities and Qualities of Light on Sexual Activity in Plants and Animals an Example of the Interaction of Genetic and Environmental Factors in Conditioning the Expression of Characters

THOMAS HUME BISSONNETTE
Trinity College, Hartford, Connecticut, and Marine Biological Laboratory, Woods Hole, Massachusetts

IT is becoming more and more evident that seasonal sexual reproduction in some plants and animals is conditioned to greater or less degree by the relative lengths of day and night, by intensity of illumination, and, in some cases, even by the color or wave-length of the light to which they are exposed. This is not equally true of all plants nor of all animals. Other factors of the environment also influence the type and time of manifestation of sexual or reproductive activity.

Whether a plant or an animal will react to one environmental factor or to another, or to several factors, by initiating sexual activity or by changing the form and degree of reproductive response depends on the genetic make-up of the organism in question. The change of the reproductive cycle, or of the sexual apparatus of organisms in response to any set of conditions, is the resultant of the interaction of the tendencies or potencies of the genetic factors inherent in the individuals in question with or against the releasing, stimulating, or inhibiting action of the factors in the environment to which these individuals are genetically responsive. The susceptibility of the organism to any set of factors is determined by its inherited potentialities, factors, or genes; the stimulation or inhibition of realization of those potentialities is controlled or conditioned by the environmental factors under which the organism finds itself or under which it has to live.

The expression of reduplication of legs in Drosophila is a good example. Under ordinary temperatures the gene for reduplication fails to cause reduplication of legs; but under lowered temperatures during development reduplicated legs appear. Reduplication, in fact, depends upon two factors—one the gene, inherent and hereditary, the other, the proper range of temperatures,[50] environmental and not inherited.

Sexual photoperiodicity is another case of such interaction of hereditary factors with or against environmental factors. In the expression of sexual activity certain hereditary factors are subject to variation in their expression with variation in the duration or intensity or quality of light—the environmental factor involved. If either the proper set of hereditary potentialities or the proper environmental conditions be lacking, sexual cycles or changes in sex-glands and accessory organs are suppressed or inhibited. In any plant or animal, the degree of activity of the sexual or reproductive apparatus at any time depends (1) on the hereditary constitution of the organism and (2) on the effective strength of the environmental factors to which it responds by increasing or decreasing its activity. In many cases it also depends upon the previous sexual activity or condition of the organism.

Even 45 years ago Curtele,[4] Vöchting,[31] and Schimper,[30] had reported observations and experiments which justified the suspicion: (1) that there was some relation between length of day or type of illumination and sexual reproduction of organisms, particularly plants; (2) that sexual cycles or activities were not entirely matters of internal rhythm, fixed by hereditary constitution alone

and entirely independent of environment; (3) that temperature cycles or food cycles might not be the major factors in the environment, if any, that condition or release seasonal reproductive cycles.

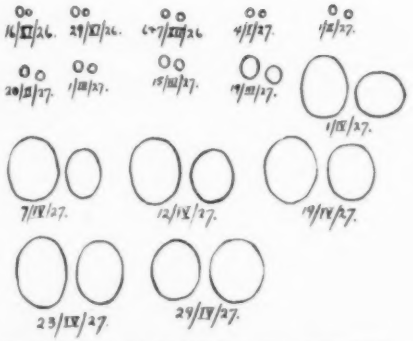
Sexual Photoperiodism in Plants

As shown by Klebs,[17] Garner and Allard,[9, 10, 11, 12, 13] Adams,[1, 2, 3] Wann,[32] and others, plants fall into three classes: (1) short-day plants, blooming when days become shorter — violets, maize, Biloxi variety of soy bean; (2) long-day plants, blooming when days become longer than a critical length—rosemallow, spinach, wheat, Sempervivum, and even the gametophyte of *Marchantia polymorpha*, a bryophytic non-flowering plant; (3) ever-blooming plants, which come into bloom without definite relation to the day-night ratio or within very broad limits of length of day—buckwheat.[16, 21] It is also noteworthy that this relation to light obtains in various plants at certain different stages in their development; all other stages may be passed successfully at lengths of day quite different from those necessary to initiate flowering at the critical photic stage.

This response to light is so localized that even the top and bottom thirds of a plant, or of single branches, may be induced to flower while the rest of the plant is kept from it, by altering the length of day for the different parts and *vice versa*.

However, Lysenko[19] shows that changes of temperature and other factors affect the stage at which plants exhibit sexual photoperiodism, and may even prevent them from reaching that stage. This factor is called "vernalization" (or "yarovization").

Even expressions of maleness and femaleness in some plants can be modified or controlled by changing the duration and intensity of the daily periods of light to which the plants are exposed (Schaffner[24-29]; Richey and Sprague,[23] and others). This was true of hemp, maize, and Jack-in-the-Pulpit, in which the sex expression may even be reversed experimentally by changing the



SEASONAL VARIATION IN SEXUAL ACTIVITY OF BIRDS

Figure 1

Comparative size of average testes taken at intervals from November 16 to May 11, showing the seasonal activity in the starling, in which the main controlling factor is the varying length of day. Other organisms have been adaptively modified so that different factors in the environment produce a maximum in sexual activity at a time when the chance for survival of offspring is greatest.

length and intensity of daily illumination.

The fundamental chemical changes in the plants associated with these responses, called "photoperiodism," are not yet determined beyond controversy. Some have suggested changes in sugar concentration,[17] in Hydrogen-ion concentration,[14] or in carbohydrate-nitrogen ratio [15, 20]. Loehwing has shown that male plants of long-day spinach and short-day hemp have higher percentages of iron, magnesium and sugar, more soluble sap constituents and greater oxidase activity than female plants.[18]

Wave-length did not seem to matter much in photoperiodism,[16] though it does have an influence on growth (Redington[22] and others) and on germination (Flint[6] and others). However, Flammarion[5] found that some plants bloomed earlier in red light than in white.[7]

Sexual Photoperiodism in Animals

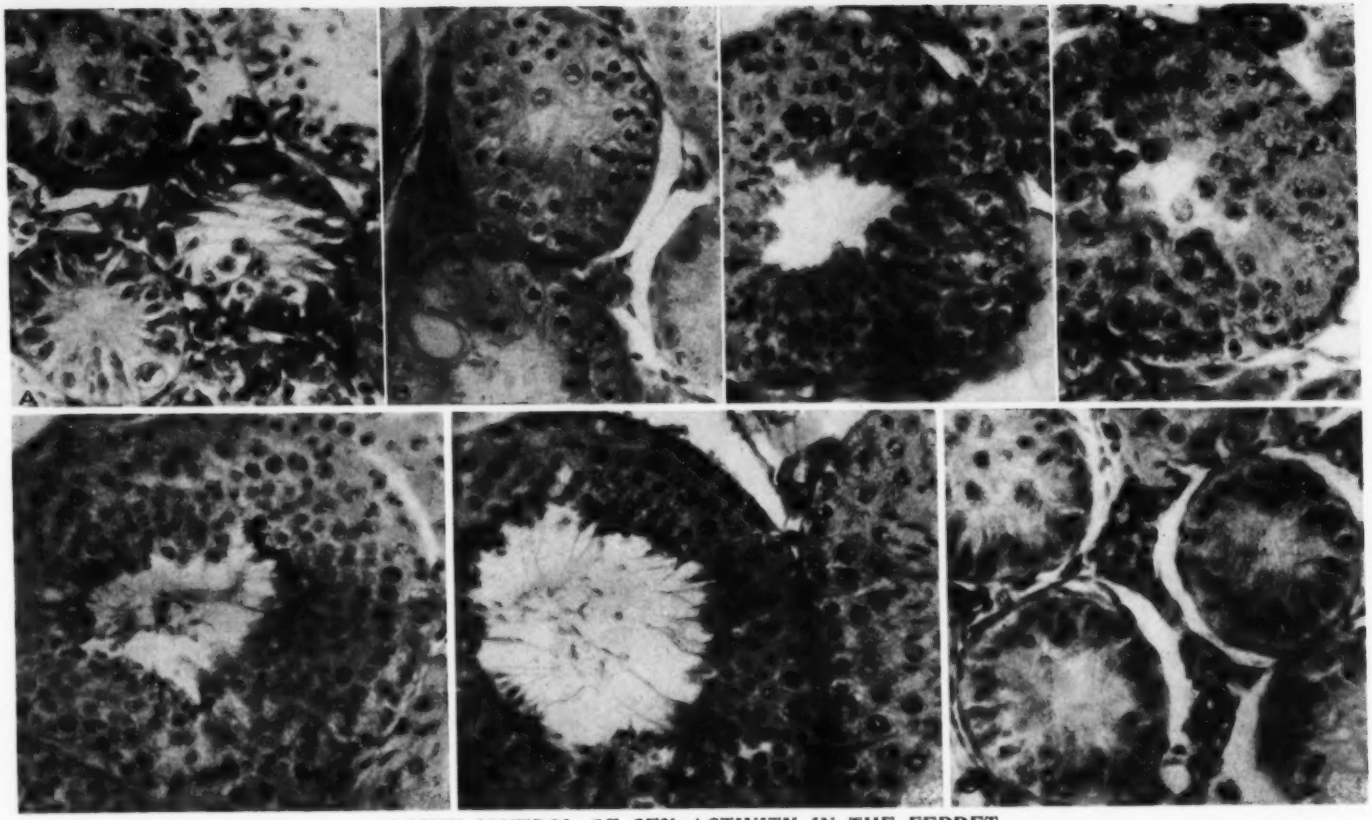
Aside from the peculiar cyclic behavior of some aquatic invertebrate ani-

TYPE OF CAGE USED IN LIGHT EXPERIMENTS ON ANIMALS
Figure 2

Cage used in experimentation with starlings on the effect of variation of length of the daily light period on sexual activity.

mals which may not be true sexual photoperiodism,[82] many terrestrial animals have been studied.* Of these, some aphids, some sheep and deer, and other animals correspond to short-day plants, coming into sexual activity in autumn, or on shortening days. Others, like ferrets, field mice, hedgehogs, juncos, crows, canaries, starlings, mejiros, turkeys, poultry, sparrows, mourning doves, ducks, pheasants, quail, grouse and some other aphids, correspond to long-day plants, coming into sexual activity in spring, or on lengthening days, though the previous light history and sexual or endocrine

*The following workers have reported on the sexual photoperiodicity of the species mentioned above: Aphids (Marcovitch, 1923), clawed toads (Zwarenstein and Shapiro, 1932, Shapiro and Shapiro, 1933), sticklebacks (Craig-Bennett, 1930), juncos, crows, and canaries (Rowan, 1925-31), starlings (Bissonnette, 1930-32; Bissonnette and Chapnick, 1930; Bissonnette and Wadlund, 1931, '32, '33; Bissonnette and Zujko, 1936), mourning doves (Cole, 1933), mejiros (Miyazaki, 1934, '35), ducks (Benoit, 1934), sparrows (Ivanov, 1935, Kerschbaum and Ringoen, 1936), turkeys, Guinea fowl (Scott, of Kansas State College of Agriculture, unpublished data), poultry (Whetham, 1933; Lippincott and Card, 1934), pheasants,



LIGHT-CONTROL OF SEX ACTIVITY IN THE FERRET

Figure 3

The "trigger-effect" of the seasonal variation in length of day in the sex-cycle in ferrets is shown in these photomicrographs (all 223×) of sections of the testes of male ferrets exposed to varying photoperiods under controlled conditions. *A* shows the normal dormant state of the testes in a male examined on October 3. No extra light had been given. The tubules, shown in cross section, are small and the central canal is practically closed. *B-E* show effects produced by exposure to about six hours of extra light (60 Watt Mazda electric light). *B* shows a comparable section on October 17, after 16 days of extra lighting; *C*, on November 7, after 36 days of light treatment. At the end of 50 days (*D*) the tubules are much enlarged and formation of sperm cells (spermatogenesis) is beginning. After 71 days of light treatment (*E*) the sexual cycle at a maximum

condition of the animals appear to determine the response to changes in day-length. Still others, like sticklebacks, ground squirrels, Guinea pigs, Guinea fowl, are not responsive to changes in day-length, but seem to respond to changes in some other environmental factor or factors instead.

Some animals, like hedgehogs, field mice, etc., are responsive to other factors (temperature, food, etc.) as well as to changes in length of day. In all animals so far investigated, improper food, so far as vitamines, proteins, fats, and salts are concerned, may act as a limiting factor which may prevent changes in sexual cycles in response to changes in length of day, or even suppress sexual cycles altogether.[52, 55, 38] Of course starvation may also prevent them.

Removal of the pituitary body (hypophysis) suppresses sexual cycles and prevents experimental alteration of these cycles by changes in length of day.[77, 78, 56] It has also been established by the author that the hypophysis undergoes histological and cytological changes in response to alteration of length of day.[53, 55, 56] In animals deprived of their hypophyses there is a slight shedding of hair soon after the operation but no marked seasonal changes of coat thereafter. The animals so treated do not manifest any sexual activity throughout the remainder of their lives, up to as long as one year and forty days, even with strong lighting which induces activity in unoperated animals in about a month or six weeks. At the climax of activity induced by lighting, both the basophil and eosinophil cells of the anterior pituitary developed large vacuoles and assumed the condition characteristic of this gland in castrated animals.

Legend to Figure 3—Concluded

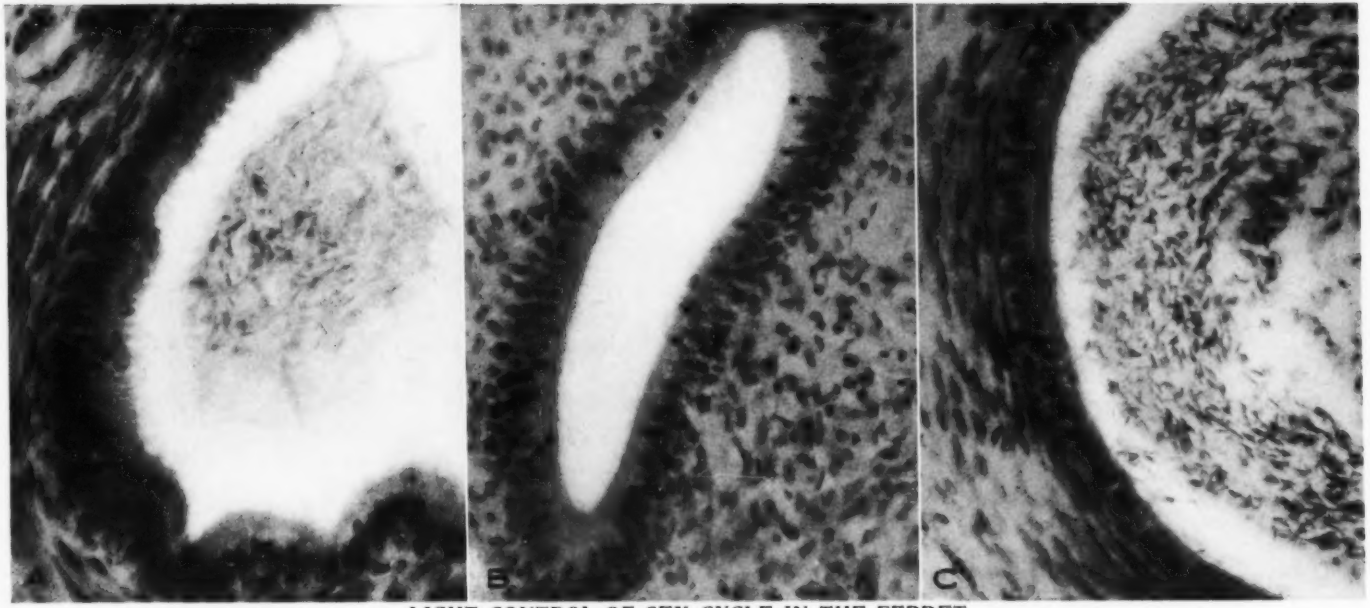
on December 12. Normally sexual activity is at a maximum from March to August. *F* shows a testis section from a control male on March 31, 76 days after experimental lighting began. That continuing light treatment does not prevent the completion of the cycle of sexual activity is shown in the final photograph (*G*), which is a section from a male exposed to 179 days of light treatment. Testicular activity has ceased and the cycle has been completed in spite of continued photostimulation.

Stimuli Transmitted through Eyes

In the animals so far studied, the eyes appear to function as the receptors for the stimulus. Animals with their eyes covered (ducks and ferrets) are not affected by increased lighting, while those with the rest of the head but not the eyes (ferrets) or the rest of the body but not the eyes (ducks, sparrows) are affected (Benoit,[40] Ivanov,[80] Bissonnette, [56] and unpublished data). Severing the optic nerves of ferrets frees the sexual cycle from the influence of the seasons and sexual activity occurs at a time of year different from the normal one (June to November, or July to December, in place of March to August) (Bissonnette,[56] and unpublished data). In ducks, complete removal of the eyeballs, however, did not prevent animals from showing the sexual effects of added lighting applied to the eyesockets.[41] Miss Ivanov[80] finds also that when the eyes of sparrows are covered, but some parts of the skin exposed by plucking, the added lighting is effective in inducing sexual activity.

In experimental modification of sexual cycles in starlings and ferrets, the time occupied by the different phases of the sexual cycle has an inverse relationship to the strength or effectiveness of the stimulus used to induce activity. Thus exposure to an extremely long

quail, and grouse (Clark, Leonard and Bump, 1936. Bissonnette & Csech, 1936), field mice (Baker and Ranson, 1932a, b, 1933), ferrets (Bissonnette, 1932, '33, '35a, b, c, d; Hill and Parkes, 1930-34; Allanson, Rowlands and Parkes, 1934; Marshall and Bowden, 1934; Hammond and Walton, 1934a, b), sheep (Marshall, 1922), hedgehogs (Allanson and Deanesly, 1934), Guinea pigs (Dempsey, Myers, Young and Jennison, 1934) and 13 lined ground squirrels (Johnson and Wade, 1930; Moore, Simmons, Wells, Zalesky and Nelson, 1934; Wells, 1934), raccoons (Bissonnette and Csech unpublished data).



LIGHT CONTROL OF SEX CYCLE IN THE FERRET

Figure 4

Sections from epididymises of males exposed to varying degrees of light treatment. *A* shows a section of part of a tubule in an animal exposed to 71 days of lighting (October 3-December 12). *B* shows a comparable section from an animal exposed to 179 days of extra light. The sexual cycle has passed its maximum and spermatozoa are no longer present in the canal. *C* shows the situation in a control male on March 31, after 76 days of extra lighting. Here also the sexual cycle is at a maximum with large numbers of spermatazoa in the canal.

day induced a significant speeding up of the sexual cycle. All animals pass the climax of reproductive activity and return to quiescence in spite of increasing lengths of day,[44, 45, 46, 51, 53, 54] just as the animals, so far investigated, do as a result of long-continued injections of gonadotropic hormones obtained from the anterior hypophysis and from pregnancy urine.* So, while sexual activity may be induced by increased lighting, and a regression of activity may be effected by reduced lighting, regression will also occur finally in spite of the stimulating agents used. In starlings this occurs before June 15th in nature.[43] With them, long-waved red light is most effective, and green and violet light seem to be inhibitory to sexual activity (Bissonnette,[46, 52] and other papers). In ferrets, all wavelengths between near infra-red and near ultra-violet appear to be equally effective.[57] In both starlings and ferrets duration and intensity of the added light periods are factors in conditioning the rate of response.[52] Temperature was not a factor conditioning response in starlings, ferrets, or juncos,[92, 94, 96, 98, 51, 53, 55, 56] but it was in sticklebacks,[68] hedgehogs,[35] and some other forms. Luminous intensity, and not total energy content, of the light was the factor concerned in the case of starlings.[46, 60, 62]

Some animals, such as starlings and female ferrets, can be brought into full sexual activity by a large initial increase in the duration of daylight or electric light, followed by declining photoperiods. Others, like the male ferrets,[55] require increasing lengths of day to be completely and quickly activitated. The ferret, however, shows an inherent rhythm of sexual activity, independent of the season, in the absence of light receptors or with optic nerves cut, but capable of adjustment to the spring season by the influence of lengthening days when the eyes are allowed to function (Bissonnette,[56] and previous papers). Ferrets with double cataracts showed no sexual cycles for two seasons or even three.[87, 56]

Amount of daily exercise does not appear to be a factor in inducing sexual activity in either starlings or ferrets,[52] but in starlings it appears to fix the trend of sex-gland change or to prolong the refractory period before changes induced by modification of length of day appear.[44] Ferrets so far gone with foot rot that they barely eat, drink, and relieve their creature activities, with almost no exercise, are as quickly stimulated to sexual activity by light as normal ones.[51] Those approaching death from tuberculosis are also susceptible of light-induced sexual activity out of the regular season even up to within twenty days of death. Some have died of this disease less than twenty days after becoming pregnant.[51]

It is suggested that the stimulus of added length of day, acting through the eyes and optic nerves, stimulates the anterior hypophysis. The increased activity of this gland acts to stimulate the sex-glands and, through them, the accessory sex-organs and behavior. The behavior affected by this cycle includes mating, nesting, etc., in some animals, unless restrained by the lack of necessary factors in their surroundings.[47, 64] Possibly migration in birds may be directly related to the cycles of the anterior hypophysis, as well as (or rather, *instead of*) to the state of activity of the sex-glands, as a part of the urge toward spring mating of migratory birds, or of the reaction from mating in autumn.[57, 58]

Reactions an Adaptive Response

It is also suggested that the different patterns of reaction to the seasonal changes in the daily photoperiod are in the nature of adaptive responses of the organism. In the countless generations of animals and plants living under dif-

*Bachman, Collip and Selye, 1934; Collip, Selye, Thomson and Williamson, 1933a, b; Collip, Selye and Thomson, 1934; Selye, Collip, and Thomson, 1934; Selye, Bachman, Thomson and Collip, 1934; Meyer and Gustus, 1935.

ferent types of seasonal environments, with different times of maximum stress and danger to eggs and offsprings, *that* type of reproductive or sexual cycle which best meets these obstacles to success or survival has been evolved through a process of natural selection in each species. Genetic differences between members of the same species, in potential reactions to environmental factors affecting the sexual cycle, must have formed the basis for this selection. Those individuals which did not produce their young in a favorable season tended to die out, because their sexual cycles were not adapted to their environment. Those individuals whose reactions resulted in the production of offspring at the season of the year when the chances for survival were greatest, would leave a larger progeny. Some groups developed a response-reaction to one factor in the environment which set off or controlled their sexual mechanism at the right time, such as the very regular change in length of day. Different species, depending somewhat on length of gestation period, sometimes became related to the light-cycle in one way, like starlings, ferrets, and long-day plants; sometimes in another, like sheep and short-day plants. Others were better served by another factor, like change of food, of temperature, of humidity or of rainfall, and were selected in relation to it.[48, 36, 37] The findings of Baker and Ransom,[37, 39] that in field mice other factors as well as light may operate, would appear to indicate that in the same species sometimes one factor acts, sometimes another. The hedgehog is even more labile in this respect. Other examples will occur to the reader. The timing of migrations may also be the result of natural selection in the same way.

We are still only in the beginnings of these studies of sexual photoperiodicity or photoperiodism, and most of our conjectures must serve only as working hypotheses, to be tested out on each species in turn, in the hope that some broad correlating principle may emerge as definite knowledge accumulates and lends itself to correlation and generalization. The keys to many of the minor parts of the great problems are still not yet shaped, but their completion are being brought nearer all the time.

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DEATH OF CHARLES V. GREEN

WE regret to announce the death by drowning of Dr. Charles V. Green, at Bar Harbor, Maine. Dr. Green was on a lone fishing expedition at the time. Evidently the canoe overturned, and in the icy water of early April he was overcome before he could reach shore. This unforunate accident occurred only a few days after Dr. Green had approved the proof of the article which appears on the next page of the Journal. Genetic science loses in this tragedy a young worker of great promise. Those who had the privilege of knowing Dr. Green personally feel that his death leaves a gap that cannot soon be filled.

Preliminary Announcement of Seventh International Genetics Congress

THE first announcement of the Organization Committee of the Seventh International Genetics Congress has just come to hand, in a letter from Dr. S. G. Levit, General Secretary of the Congress.

"We are pleased to inform you that the Seventh International Congress of Genetics will be held in the USSR in 1937. It is planned to have the sessions in Moscow, in the second half of August. The preparations for the Congress have been initiated by the Organization Committee which has for president A. I. Muralov (president of the Lenin Academy of Agricultural Sciences), vice-presidents, N. I. Vavilov and V. L. Komarov, general secretary S. G. Levit, and members N. P. Gorbunov, G. D. Karpechenko, B. A. Keller, N. K. Koltzoff, T. D. Lysenko, G. K. Meister, H. J. Muller, M. S. Navashin, and A. S. Serebrovsky.

All scientists working in the field of genetics are invited to present their contributions. The titles and abstracts should reach the Organization Committee before February 15th, 1937. Detailed information concerning the program, membership, exhibits, lodging and transportation is being prepared. Excursions to various parts of the USSR are on the schedule. Suggestions concerning the program or other features of the Congress will be appreciated."

Communications to the Congress should be addressed to the General Secretary, Dr. S. G. Levit, Academy of Sciences, Bolshaya Kaluzhskaya, 75, Moscow, USSR. Telegrams should be addressed Moscow Genetica. Geneticists interested in receiving notices regarding the Congress are invited to send their names to Dr. Levit. A.G.A. members who wish to be put on the Congress mailing list to receive material may send their names to the Association. It is planned to forward these names at weekly intervals by registered mail.

MULTIPLE LETHAL GENES IN THE MOUSE

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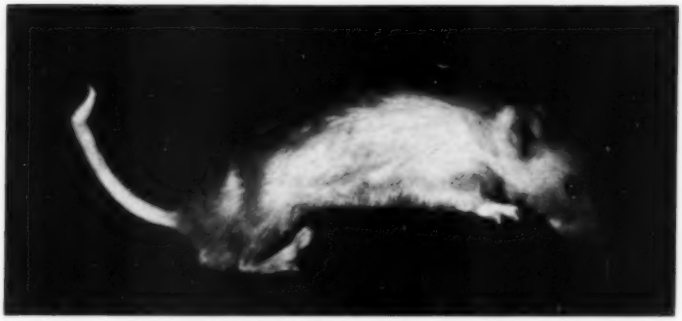

FOUR LETHAL GENES NOT FATAL
Figure 5

This mouse has inherited from his parents single "doses" of four lethal genes. If he were homozygous for any of these genes he would not have survived. It is clear that genes which produce effects fatal to the organism are not cooperativbe in their activities, so that being heterozygous for several has not the same effect as being homozygous for one of them.

OF the exceptions to usual Mendelian inheritance, dominant lethals were among the first observed. Typically, in mutations of this class, homozygotes are non-viable, perishing either in embryonic life or shortly after birth. Consequently all individuals exhibiting such a mutation are heterozygous and never breed true, while the F_1 mutant hybrids from outcrosses to normals when mated *inter se* produce a 2:1 instead of the usual 3:1 ratio in the F_2 generation. Mutations of this type may be conditioned by a single gene or may result from deficiencies in which one or more genes in the deleted section of the chromosome lack sufficient potency in the haploid condition to bring about normal development. The changes may be general in their action, as Sinnott and Dunn[8] have pointed out, but occur at such a time in development that one region or organ which is at a critical stage is chiefly affected.

Dominant lethal mutations are widespread among animals. Many are known in Drosophila, a number of which, including Gull and the Notches, have been demonstrated to result from deficiencies. The Creeper fowl,[4] in which the heterozygote is characterized by shortened legs, illustrates this phenomenon in birds. Among mammals, Wright[9] has described one type of polydactylous guinea pigs in which the homozygote dies before birth, while Greene, Hu, and Brown[3] noted a case in rabbits in which the mutant gene exerts a dwarfing effect on the heterozygote but kills the homozygote. Little[6] has suggested that yellow in Toy Griffon dogs may similarly be a dominant lethal character.

Mutations of this type seem relatively frequent in mice as compared with other mammals. Of the four mutations dominant to the wild type—excluding white-bellied agouti, found in certain wild sub-species—which have been re-

ported in *Mus musculus*, all are either lethal or semi-lethal. Mice homozygous for the gene for yellow coat color (A^y) or for brachyury (T) die early in embryonic life while individuals with two doses of the dominant spotting gene (W) may live—despite their anemic condition—for some days or even weeks after birth. The gene for naked (N) should properly be termed semi-lethal for an occasional homozygote may even reach maturity. Because of their characteristic lethal action when homozygous, it may be that some of the four are in reality deficiencies instead of gene mutations, an explanation which Dobrovolskaia-Zavadskaia[1] has advanced in discussing the action of T.

Since two doses of the same dominant gene (or deficiency) as a rule prove fatal to the organism, it is of interest to learn whether mutations of this class have a cumulative effect when heterozygous, i.e., whether one dose each of two or more in combination will similarly exert a lethal effect. Schultz[7], investigating the dominant mutations in *Drosophila melanogaster* known as *Minutes* which are lethal when homozygous, found that in no case was a combination of *Minutes* at different loci lethal. On the contrary, when Delta, having similar properties, was combined with certain ones of the *Minutes*, the fly was almost always non-viable. Whether a like situation extends to mammals can best be tested in the mouse in which eleven different combinations of two or more such mutations can theoretically be synthesized.

Little[5] reported that mice heterozygous for both A^y and W were normal in regard to viability, while the writer[2] showed that A^y and T could coexist heterozygously despite the early embryonic lethal effect of each in a double dose. To ascertain whether more than two dominants could be present in the same animal without ill effects, yellow brachyuric females were mated to a dominant spotted naked male.

In the first four litters, totalling 22 offspring, one male with four dominant mutations, the maximum number possible in the mouse, was found. A photograph of this animal is shown in the accompanying figure. In appearance the mouse is typical for the dominant characters in the respective parental stocks, although it is not yet old enough for it to be determined whether the adiposity associated with yellow coat color will develop. Of the sixteen expected classes in this cross, fourteen were observed with a distribution close to that anticipated. Either in the same cross or in others all eleven possible combinations with two or more dominant mutations have been recognized.

It is obvious that the dominant lethals in the mouse are not cumulative in action and that, although two doses of any one are lethal, a total of four doses of different mutations does not necessarily entail the death of the zygote.

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FLORAL ABNORMALITIES IN SORGHUM

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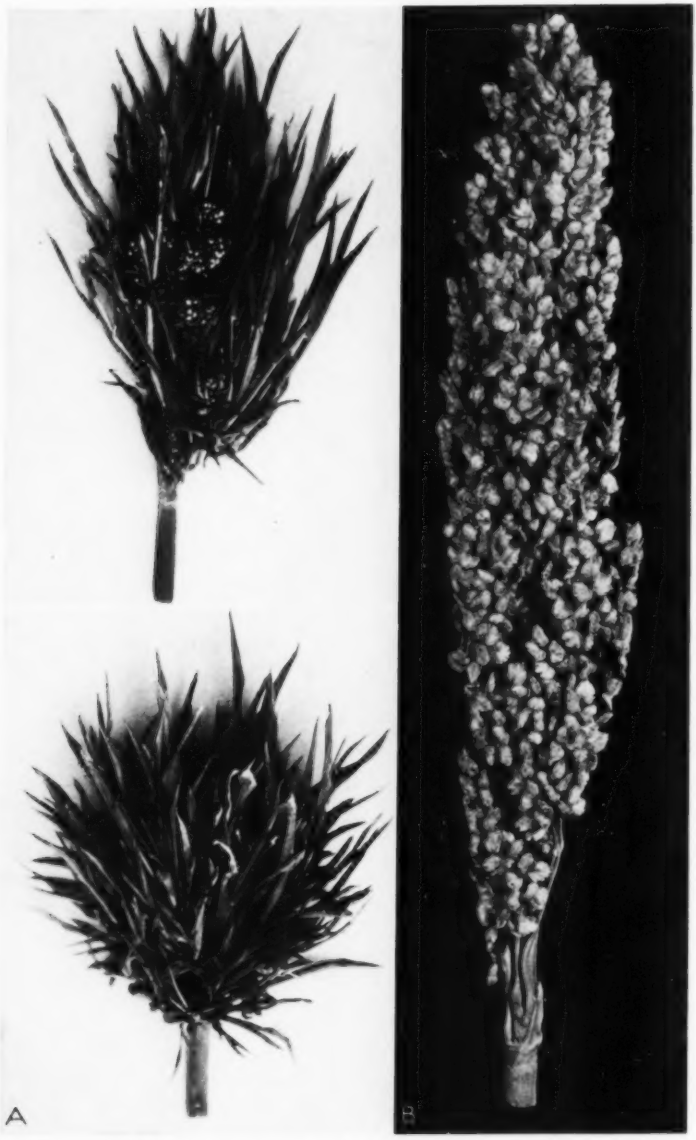
MANY unusual developments in flowers and modifications of floral organs have been reported in the Gramineae but only a few of these reports have dealt with Sorghum primarily, perhaps, because the sorghums have not been as intensively studied as some of the cereals and not because anomalies in this crop are not of equally frequent occurrence. The floral abnormalities herein reported include both heritable and non-heritable types observed over a period of several years. It is notable that there is a close parallelism between these anomalous types in the genus Sorghum, a member of the Andropogonae tribe, and those previously reported in maize belonging to the tribe Tripsaceae. Six of these abnormalities reported in sorghum are analogous to cases already described in maize.

The normal sorghum inflorescence is a panicle, consisting of a central axis or rachis from which lateral axes branch in more or less definite whorls; the secondary axes further branch until several orders may be found. The panicle branches bear spikelets in groups of two, one sessile and one pedicellate, except that the terminal spikelets of a branch usually occur in threes, two of which are pedicellate. The sessile spikelet consists of two broad, thickened, leathery glumes, the lower partly enfolding the upper, and within the glumes two flowers, the lower abortive with a lemma the only remnant, and the upper complete with lemma, palea, two lodicules, three stamens, and an ovary with two stigmas. The pedicellate spikelets are narrow and the somewhat less thickened glumes may be empty or may enclose the lemma of an aborted lower flower, and the lemma, palea rarely, lodicules, and stamens of a staminate upper flower; rarely the pistil is present.

Spikelet Shoots

An interesting abnormality not previously reported in Sorghum is the asexual reproduction of new plants from tissues which normally give rise to sexual organs, thus producing shoots or buds instead of seed within the spikelet (Figure 6-*A*). In October, 1932, D. L. Jones and R. E. Karper examined a field of Texas Blackhul kafir at Amherst, Texas, from which County Agent D. A. Adams had procured an abnormal head of sorghum. Scattered at random over some 15 acres on the north side of this 30-acre kafir field many abnormal heads, bearing plantlets up to 5 inches long, were found. Among 300 plants examined 72 were abnormal. This field was planted with certified Texas Blackhul kafir seed produced by J. W. Hammock, another farmer in the vicinity, who had obtained his stock from the Lubbock Experiment Station the previous year. No such abnormalities appeared on the Hammock farm, planted from the same seed stock, and none was encountered on the Station before or since. Neither did the South half of this field, planted to the same seed, contain any of them, but there had been a few days' difference in the time of planting the two parts of the field. It appears that this variation of a few days may have brought into play a different set of environmental factors in the life of the plant which profoundly affected its reprduction process. Since not all the plants were af-



ABNORMAL SPIKELET-FORMS IN SORGHUM

Figure 6

A shows a variation in the sorghum flowerhead in which, instead of making seed, young plants arise throughout the inflorescence. These are interspersed with normal seed-bearing spikelets. Whether the young plants originate from the embryo sac or whether they are merely vegetative buds from the flower primordium is not certain. Among 300 plants in a single field 72 showed this abnormality.

B—Another striking floral modification appeared as a single head in a large field of sorghum. In this the seeds are replaced by scaly proliferations, which resemble the lemmas of certain grasses. All of the spikelets on the head are similarly modified, and no seed was produced.

fected, and since those producing spikelet shoots were scattered through the field, it would seem that the genetic constitution of the individual plant determined whether it would respond to this environmental stimulus by producing abnormal spikelets.

The number of vegetative shoots replacing the normal seed in the spikelets varies widely in different heads, ranging from only a few to practically 100 per cent replacement of the seed by plantlets. The heads are also abnormal, having a relatively short rachis, comparatively few seed branches, and although about the same size as normal heads, they are irregularly shaped and lack cylindrical form. Also, the plants bearing these heads were abnormal, profusely tillering and producing a bunchy growth readily distinguished, at considerable distance, from normal plants.

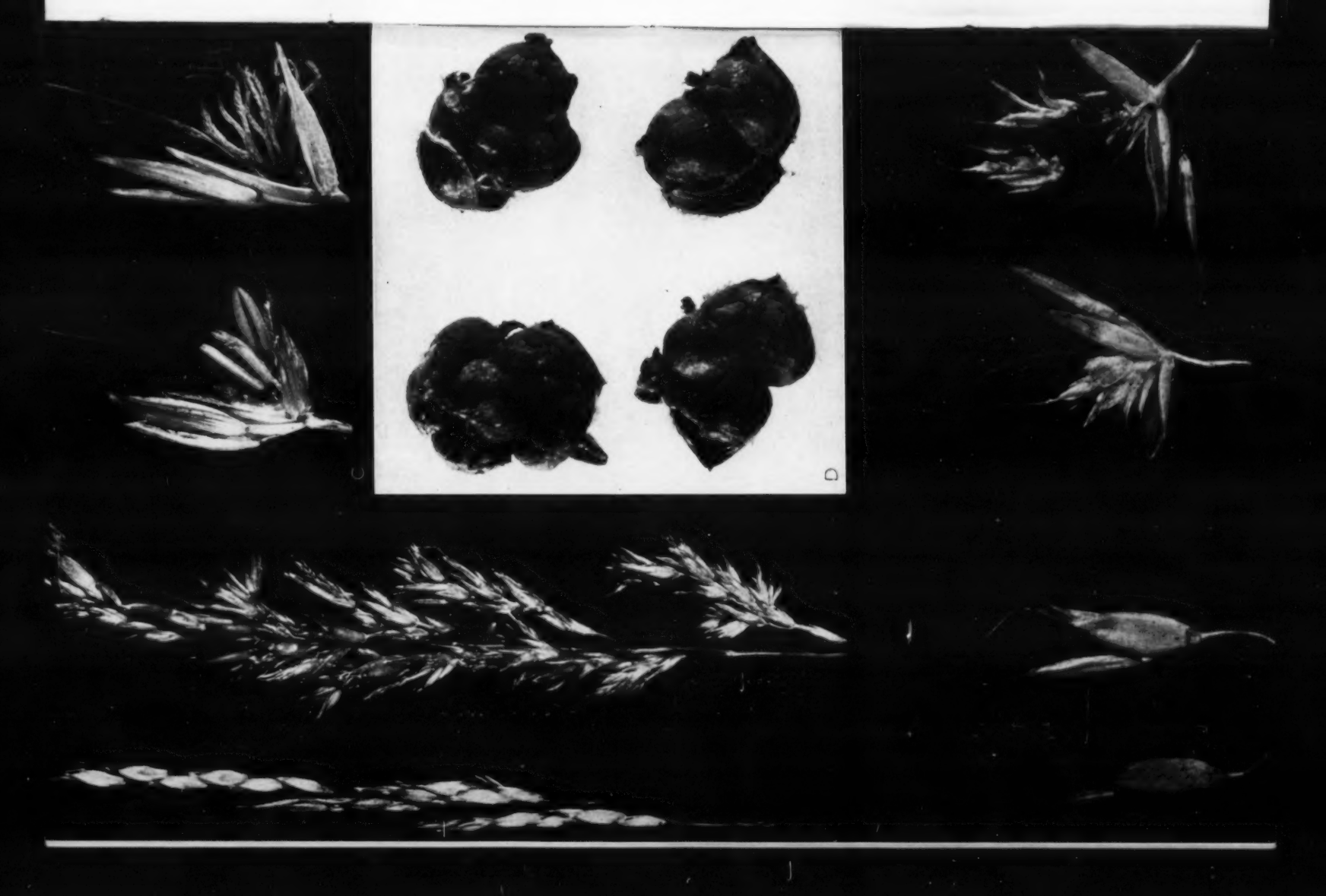
Normal seed-bearing spikelets are interspersed with the shoots throughout the inflorescence. In the abnormal spikelets the outer glumes are regular but between them is a shoot consisting of a small stem bearing leaves which may vary considerably in form. Many of the leaves are very similar to normal vegetative leaves in that they are differentiated into blade and sheath. While the basal leaves are sometimes very short and scale-like, they are usually similar to the early leaves of normal sorghum plants. The length of the shoots varies from a fraction of an inch to five inches. No roots or root-like structures were found. No trace of vegetative organs of the spikelet, such as sterile lemma and palea, were found between the glumes. The pedicelled spikelet was present and normal but some of the sessile spikelets were empty, containing neither seed nor shoot.

The shoot closely resembles the young sporophyte of sorghums and the phenomenon is almost identical with the occurrence described by Collins[4] as apogamy in maize. Some form of apomixis, such as apogamy or sporophytic budding, may be the correct interpretation of this anomaly in Sorghum but definite evidence from which to determine the point is lacking. If true apomixis were the explanation, these young sporophytes arose from some part of the unfertilized embryo sac and would lack a direct vascular connection with the mother plant. The size of the shoots, however, would indicate that they do have a vascular connection, in which case the anomaly could be best explained by assuming it to be merely a leafy proliferation of the flower primordia. In some respects the shoots resemble viviparous growths but they are not true vivipary which term should be confined to the germination of seeds *in situ*. These shoots did not arise from seeds. Although the ability of these young sporophytes to support themselves and survive independently of the mother plant was not tested, it is probable that the stems of the young shoots, if potted off, would have developed roots since it has been found that sorghums can be propagated readily from stem cuttings.[8]

Approximately 50 plant rows producing approximately 40,000 plants were grown the following year from heads of both abnormal and normal plants collected from this field but none of the abnormalities was reproduced, thus establishing the fact that the character is not hereditary—at least, not visibly hereditary under the environmental conditions obtaining that season. The most likely cause of the phenomenon appears to be an unusual combination of environmental factors encountered by these particular plants at a critical stage in the early development of the reproductive organs.

Scaly Proliferation

Another curious abnormality affecting the floral organs was found in a field of Texas Blackhul kafir by J. W. Hammock, in 1933, on his farm near Sudan, Texas. Only a single head of its kind (Figure 6-*B*) was found in the field which was planted to pure seed stock recently received from the Lubbock Experiment Station. An identical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case of a single abnormality of this kind was described by Laude and Gates[6] as it occurred in Kansas a few years ago. Since they have given a full botanical description of it, a brief mention of a second appearance of this unusual modification of the floral parts will suffice.

The outer glumes are regular. Instead of enclosing a floret, however, they enclose an axis which usually reaches a length of 6 or 8 millimeters. To this axis are attached alternating scales, the upper of which is shorter than the lower (Figure 8-*E*). These bracts bear a striking resemblance to the lemmas of Eragrostis, and as a result the bilateral spikelet also resembles that of Eragrostis. Upon closer examination, however, this resemblance is found to be entirely superficial as, instead of bearing flowers between the glume-like bracts, the flowering parts are usually absent. Toward the tip end of some of the leafy proliferations both pistils and stamens were found to be present. All of the spikelets on the panicle are similarly modified, the whole structure consisting of 30 to 40 scales, or bracts, with some of the floral parts occasionally present, but no seed are produced.

The initial stage of this modification evidently takes place in the primordium of the flower. Apparently the part of the primordium which ordinarily develops into the florets, containing reproductive organs, remains entirely vegetative except for the occasional addition of floral parts. As in the case of the spikelet shoots, the glumes enclose a modified leafy structure; however, the modifications found in the leaves are quite different.

This succession of glume-like bracts, or leaf modifications, appears to be the result of a transformation and vegetative proliferation of some of the floral parts within the spikelet. As the defect does not seem to be inherited it is probably the result of environmental effects, or may have been caused by an early disturbance from a bacterial or virus invasion of the plant.

Antherless Flowers

Two plants with flowers containing no anthers but several ovaries were found in 1929 in the progeny of a dwarf Sudan grass selection which had been bagged in 1928. A few seed resulting from natural cross-pollination developed and several were obtained by hand pollination using pollen from normal Sudan and from four varieties of sorghum: Dwarf Yellow milo, Texas Blackhul kafir, Dwarf feterita, and Sumac sorgo. The progenies of these

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MULTIPLE PISTILS AND MULTIPLE SPIKELETS—INHERITED CHARACTERS IN SORGHUM

Figure 7

A-B—The "spikelet-within-a-spikelet" character in sorghum. At *A* is shown on the left a spikelet of tunis grass in contrast with a branch of multiflorous sorghum at the right. This profuse multiplication of spikelets, replacing the normal flower organs, results in complete sterility among the homozygous recessive plants. At *B* are shown details of the structure of the extra spikelet. On the left is a normal pair of closed spikelets compared with a multiflorous pair showing the supernumerary awns protruding. At the right are two of the abnormal spikelets partly dissected to show the transformation of floral organs into secondary spikelets. The superficial awned lemmas are conspicuous. *C* and *D* show another heritable form of flower abnormality, which may have economic value. This form is called multiple pistils, and in it the stamens of the normal flower are replaced by pistils. At *C* on the left is shown a normal sorghum flower showing two pedicelled spikelets and the sessile spikelet containing three stamens, a stigma, and the awned lemma. At the right is shown a similar flower from the antherless form. Here a multiplicity of pistils entirely replaces the stamens. Since this form produces no pollen it may have economic value in the production of F_1 hybrid seed, for by interplanting in isolated plots with a pollen-bearing variety all seed on the multiple-pistil plants would necessarily be hybrid. *D* shows the seed produced by pollinating the multiple pistil flowers. Wind-blown pollen from neighboring plants with normal stamens is necessary to fertilize these forms, and the well developed multiple seeds germinate and produce normal plants. The photograph shows two, three, four, and six-seeded spikelets. The antherless form is inherited as a simple recessive character.

early crosses and others made later were used to determine the mode of inheritance and to incorporate the character into other varieties and strains of sorghum.

Similar cases of supernumerary ovaries in the Gramineae have been reported, as carpellody in maize, by Weatherwax,[10] and pistillody in wheat flowers, by Leighty and Sando.[7] Typical antherless spikelets in sorghum (Figure 7-*C*) contain, within the outer glumes, a sterile lemma, fertile lemma, and palea placed in normal sequence. No lodicules, filaments, or anthers are present. There is always one well-formed ovary, and it usually is surmounted by two stigmas, although occasionally only one, or again a third, stigma may be found. Surrounding the central ovary there are most frequently three other ovaries, but smaller or larger numbers are not uncommon, and as many as six others have been found (Table I). The secondary ovaries usually are smaller than the central ovary and often are somewhat crescent shaped, probably because of pressure against the primary ovary during development. They commonly have one or two stigmas, but three have been observed in rare instances. Generally each flower contains some ovaries with two stigmas and some with one, although occasionally all secondary ovaries have two stigmas or all have only one.

Fused to the inside of secondary ovaries at various points and for various distances there are usually, but not always, some blister-like growths which in color and substance appear similar to the lodicules of normal flowers. These protuberances, however, do not function as lodicules do in the ordinary process of blooming — that is, swell rapidly and then shrink within a period of a few hours—but they slowly grow or enlarge until at times they become considerably larger than the ovaries. After a period of time varying from a few days to two or three weeks these growths gradually dry up.

TABLE I. Frequency of number of ovaries in antherless flowers.

	Supplementary ovaries						
	1	2	3	4	5	6	Total
Flowers	1	9	69	11	4	1	95

Since no lodicules are present, antherless flowers do not "bloom" in the usual sense, but instead the glumes are forced apart by the mass of stigmas, and once open the flowers do not close. The stigmas are thus exposed and subject to pollination. In some hybrid lines which have been developed, and under certain environmental conditions, only a few spikelets are forced open because of relatively large glumes and small pistils. When this physical condition is reversed and the glumes are relatively small compared to the mass within them, the flowers of the entire inflorescence are exposed.

The number of seed developing in individual spikelets of an antherless panicle varies with the number of ovaries and the physical conditions affecting exposure of stigmas to windblown pollen. Usually there are only one or two well-developed seed, but three or four are not uncommon and six have been found (Figure 7-*D*). These seed are somewhat misshapen because of their crowded condition in the spikelet, and frequently part of them shrivel up, probably because nutritional devices are not adequate to nourish properly several seed in one spikelet. Well-developed seed from secondary ovaries, however, germinate and produce normal plants.

Occasional modifications of the above described type occur. These modifications, with some additional anomalies, are of the sort reported and illustrated by Anthony[1] and by Leighty and Sando[7] in wheat, and Bledsoe[3] in rye and wheat × rye hybrids. Practically all degrees of metamorphosis of the stamens from normal hermaphroditic flowers to wholly pistillate flowers have been observed, and the partial or complete transformation of stamens and lodicules to fleshy growths and bracts is common. These modifications have appeared in certain progenies of only

a few crosses but are found abundantly in these progenies.

The typical antherless condition is recessive to normal and is simple in inheritance. It may be seen in Table II that there is a slight deficiency in the antherless class, and in the antherless × Sumac sorgo cross the deficiency is a significant deviation from the 25 per cent of recessives expected.

Since sorghum flowers normally are bisexual and the inflorescence is largely self-fertilized, the two common methods of obtaining crossed seed are by removal of the anthers in individual flowers by hand or by a recently developed method[9] involving the immersion of the inflorescence in hot water to kill the pollen, with subsequent controlled pollination in either case. The latter method is adequate for the production of F_1 seed in quantities needed for any experimental purposes and possibly for field plantings, provided a more efficient method cannot be evolved.

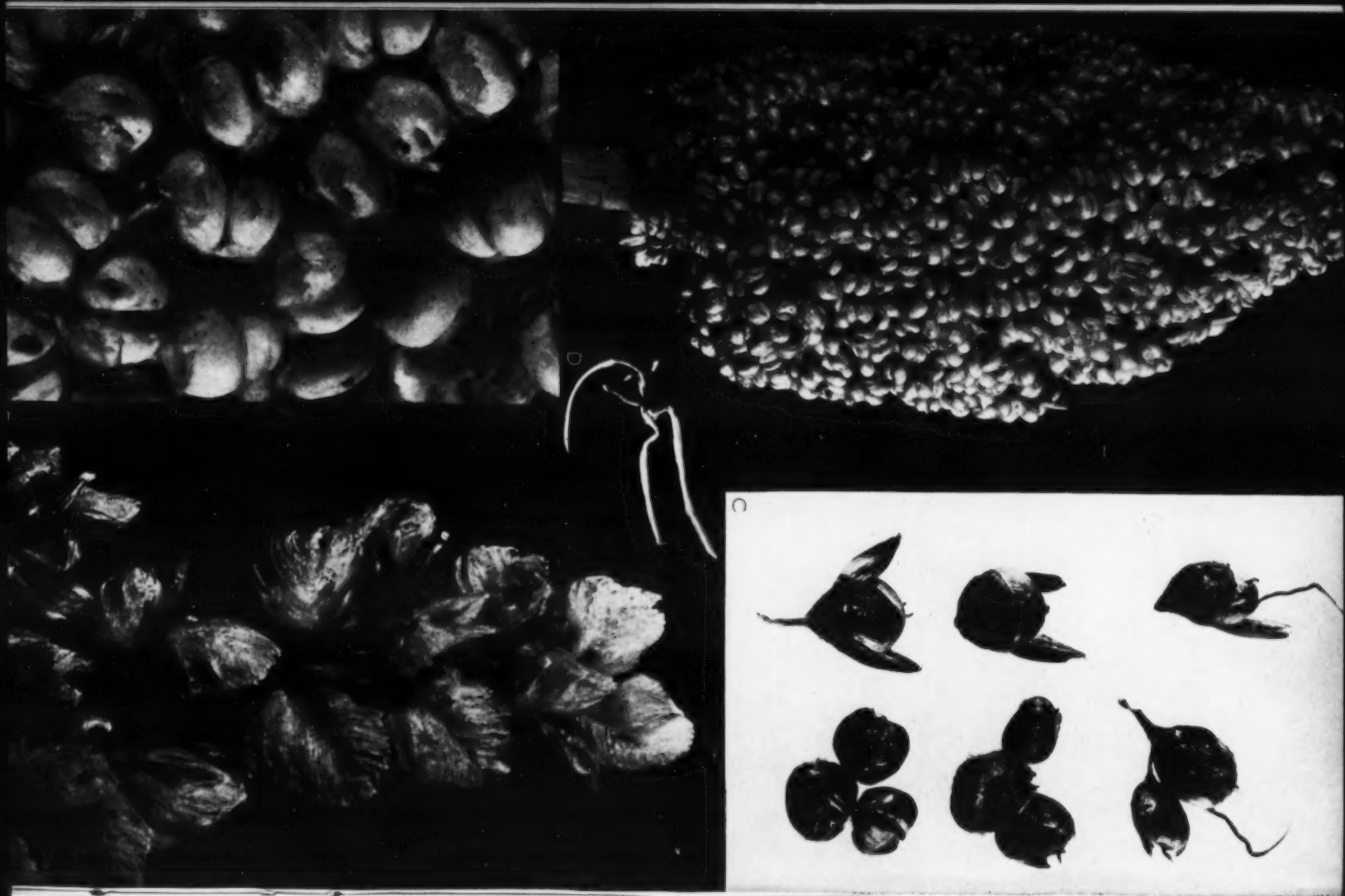
Many factors for male sterility or semi-sterility are known in corn, and efforts have been made to isolate pollen-sterile lines in sorghum, but none has been obtained by the writers or reported by others. The antherless character found in Sudan is the nearest approach to the desired condition, and this character is being transferred to most of the common varieties of sorghum. In 1935, the F_2 generation of the second back-cross to Sumac sorgo, Texas Blackhul kafir, and Spur feterita was grown.

Effective utilization of the antherless character in the production of crossed seed for farm plantings will require developments along several lines. Since antherless cannot be carried in the homozygous state, a closely linked endosperm, seedling, or plant character is desirable to make possible the identification of antherless plants previous to blooming. Lines must be established in which the stigmas will be well exposed on antherless plants to provide ample opportunity for pollination by wind-blown pollen from adjacent selected pollen parent rows. And finally, yield tests of hybrid lines must be conducted to select varieties or strains for parent stocks. To have any appreciable value the crop from crossed seed necessarily must produce grain considerably in excess of any standard varieties and at the same time must be sufficiently dwarf and early to be handled economically by the farmer.

First generation sorghum hybrids display marked vigor as expressed in height of plant, lateness of maturity, and in both vegetative and grain production. Karper and Quinby have found, as shown in unpublished data, as much as a three-fold increase above

TABLE II. Segregation in the F_2 of Antherless Crosses.

Cross	*Normal*	*Antherless*	*Per cent recessive*	*P*
Antherless natural hybrid	663	213	24.32	
	595	192	24.40	
	129	40	23.67	
	138	39	22.03	
TOTAL	1,525	484	24.09	>.30
Antherless × Sumac sorgo	372	81	17.88	
	189	51	21.25	
	217	59	21.38	
	320	64	16.67	
TOTAL	1,098	255	18.85	<.01
Antherless × Texas Bh. kafir	197	75	27.57	
	50	16	24.24	
	113	26	18.71	
TOTAL	360	117	24.53	>.80
Antherless × Spur feterita	271	92	25.34	
	315	94	22.98	
TOTAL	586	186	24.09	>.50



either parent in both grain and forage production of F_1 hybrids. The extent of the increase was found to be dependent on the parental combinations used. In some combinations grain yield is increased without an appreciable increase in height of plant, and maturity is not delayed. Thus, it seems possible that through the utilization of the antherless character a practicable method may be evolved for the production of F_1 seed for commercial plantings of sorghum.

Multiflorous

Variable development of the floral organs in sorghum was encountered in another case which we have called multiflorous. A somewhat similar anomaly of many-flowered spikelets in maize has been described by Weatherwax.[11] The multiflorous abnormality is also a proliferation of spikelets but is an hereditary one depending upon a genetic factor for its expression. The character was discovered in a plant row of Tunis grass (*Sorghum virgatus*) grown from old seed in 1930. The parent seed was supposed to be from selfed stock last grown at the Chula Vista Forage Crops Station in 1917. Apparently this old seed which germinated poorly producing only eight plants in the row was from a heterozygous head, since three of them were homozygous recessives in which the peculiarity was first observed.

The abnormality is a proliferation resulting in the production of spikelets within a spikelet (Figure 7-*B*) and both stamens and pistils are usually absent. Within the outer glumes are found the awned fertile lemma, sterile lemma and palea but only rarely are either anthers or stigmas found and then these structures may have undergone considerable modification. In the place of stamens and pistil, metamorphosis of these parts into other spikelets with regular glumes, awned lemma, sterile lemma and palea occurs, but the remaining parts of the flower are again modified or abortive. Within these latter spikelets of the second order, of which there may be from two to four fairly well-developed within the primary sessile spikelet, another spikelet of the third order sometimes develops. Whenever normal differentiation into pistils and stamens is accomplished proliferation ceases in that particular part of the spikelet. Until this occurs, or the spikelets mature, however, a profuse multiplication of spikelets accompanied by irregular modifications and abortion of parts takes place. No seed have been found although they may be rarely produced since anthers and pistil are sometimes formed.

The pedicelled member of the pri-

TWIN-SEEDED AND OTHER FLOWER ABNORMALITIES

Figure 8

A and *B* show a head of twin-seeded sorghum and a "close-up" of part of such a head. The twin seeds result from the development of the lower flower of the spikelet, which is normally abortive, and is represented only by the lemma. This type of double seed is inherited whereas the development of two seeds from the same flower, an abnormality which occasionally occurs, appears to be due to environmental factors. In the enlargement (*B*) of a section of a twin-seeded panicle both twin-seeded and single-seeded spikelets may be observed. This character was brought into the United States from India in varieties imported in 1932. The twin-seed tendency is a mendelian dominant to the abortion of the lower flower of the spikelet—the situation in most varieties. *C* shows a form in which the normally non-functional pedicelled spikelets are fertile. In this form the flower or flowers of the spikelets produce groups of two or three viable seeds instead of a single seed. Such groups are shown at the right, and at the left the "normal" condition in which the basal flower only gives rise to a seed. This variation is most frequently found in Milo varieties so that it probably has an hereditary basis, though its variable manifestation suggests that environment is important in expression of the character. At *D* are shown twin plants produced from a single seed. The seed was from a cross between Kafir and Milo, and was from a chlorophyll deficient region of a head, so that both the plants lacked chlorophyll and therefore did not survive. Apparently the seed had developed from a single fertilized egg. *E* shows a close-up view of the scaly proliferation shown in Figure 6. The detailed photograph shows the remarkably complex modification in the floral parts which was characteristic of the entire head.

mary pair of spikelets is present and normal. Sessile spikelets of the second order are usually accompanied by the other members of the pair, the pedicelled spikelet, in which modification and proliferation sometimes occurs.

Mature plants of this abnormal type tiller more profusely and produce a more luxuriant vegetative growth as a result of their sterility than do the normal plants. They are easily identified in a segregating population not only from the plants themselves but there is considerable difference in the panicles. In the multiflorus type marked proliferation in the many spikelets greatly increases the size of the panicle and the enlarged spikelets with a multiplicity of awns protruding (Figure 7-*A*) are readily recognized.

Inheritance of the mutiflorous character is simple and recessive. Three defectives appeared among the eight plants in the original plant-row. Three out of the five normal plants produced segregating populations the following year but because of poor stands unsatisfactory counts from small populations were obtained. Finally from eight plant rows, six segregating populations were obtained which produced a total of 1,448 normals and 441 recessives or a shortage of 31 plants in the recessive class. A value of $P = .10$ indicates that this distribution does not deviate significantly from a 3:1 ratio.

Heritable Twin-Seed

Among the importations of sorghum seed from India there have been several durra varieties which normally bear two seeds in some of the spikelets. Seed of such varieties was secured from H. N. Vinall, Division of Forage Crops and Diseases, U. S. Department of Agriculture, in the spring of 1932. Most of the twin-seeded durras planted have failed to reach maturity in the growing season at Chillicothe, but one variety, F. P. I. No. 14641, usually matures seed.

A cursory examination of herbarium heads of the varieties introduced indicates that the proportion of spikelets in which two seed develop ranges from around 20 per cent in some varieties to above 90 per cent in others. F. P. I. No. 14641 usually bears 70 to 80 per cent of twin seeds (Figure 8-*A, B*), but apparently seasonal conditions influence the development of the extra seed, and at times less than 50 per cent of twins are found in this variety.

Examination of individual spikelets clearly shows that the twin-seeded condition in these durras is a result of development of the lower flower of the spikelets to a functional stage, analogous to two-flowered pistillate spikelets found in some varieties of maize. This lower flower is normally abortive in sorghum, the only remnant being the lemma. In the twin-seeded durras, spikelets dissected at the blooming stage usually have all structures present for both flowers. The lower flower is a little slower developing than the upper. With the exception of the lemma the parts usually are slightly smaller, and ordinarily it blooms from a few hours to a day later.

Single-seeded spikelets in twin-seeded varieties generally are due to incomplete development of the lower flower; however, occasionaly one of the flowers appears to be unfertilized although complete structurally. The parts most frequently failing of full development are the stigmas; often the brush is thin or entirely absent, thus eliminating the possibility of fertilization. Occasionally other organs, such as the lodicules, one or more anthers, or even the ovary, may be absent.

Pedicelled spikelets in the twin-seeded durras are also two-flowered but staminate. Two complete sets of bracts, lodicules, and stamens may be present, or, as in sessile spikelets, some of the parts frequently fail to develop.

The functional condition of the lower flower is a single-factor heritable character dominant to abortion. Several F_1 hybrids of crosses between twin-seeded durra and common single-seeded varieties have shown approximately the same percentages of twin-seeded spike-

lets as are found in the durra parent. An F_2 population, grown in 1935, contained 53 plants with single-seeded spikelets only, or 28 per cent, out of a total of 188 plants. This population was small but the P value ($>.30$) shows the segregation to be within expectation for a 3:1 ratio.

Multiple-Seeded Spikelets

Multiple-seeded spikelets frequently are observed in fields of sorghum, particularly in fields of milo or milo hybrids. This occurrence has been described by Karper[5] in an earlier paper but these observations were based only on mature panicles. Since the inner bracts of sorghum spikelets are papery and fragile, it is difficult to dissect mature spikelets and determine definitely the location of various structures.

In the late fall of 1934, a large number of spikelets from blooming panicles of milo and milo hybrids were examined. No spikelets were found in which the lower, or normally abortive, flower had developed. In three cases the upper flower contained two separate ovaries, each surmounted by two stigmas; all other parts of a normal spikelet were present and properly located in each instance. In a fourth case the upper flower had two partially fused ovaries within two normal lodicules, but five anthers were present; no extra bracts were found.

While this limited examination does not preclude the assumption that the lower flowers of spikelets sometimes develop to a functional stage in our commonly cultivated varieties, it does indicate that at least in some cases double seeds arise from two fertilized ovaries within one flower. This condition is not due to a metamorphosis of another organ into an ovary because other normal structures are present, but it may be the result of some stimulus causing a division of the growing point from which the single ovary normally develops. There may be an inherited tendency for the formation of this type of multiple ovaries since it is most frequently found in milo or milo hybrids, but the expression of the anomaly seems to be caused by environment.

Polyembryony

A case of polyembryony in sorghum was encountered in an F_1 seed of a cross between kafir and milo. The flower used as the female in this cross was in a chlorophyll deficient area of a head used in a study of the maternal inheritance of chlorophyll; hence the resulting seedlings lived only through the seedling stage. Both seedlings exhibited the expected chlorophyll deficiency. This seed, which appeared normal, was planted in a paper pot and gave rise to two well developed seedlings (Figure 8-*D*), each with its own plumule and radicle but both seedlings probably developed from the same embryo. When dug up later for examination of the old seed, the two plants were loosely attached to each other and the parent seed. While definite determination at that stage was not possible, it appeared that the two seedlings had a common scutellum.

Fertile Pedicelled Spikelets

Sorghum spikelets are usually borne in pairs. One spikelet of the pair is sessile, broad and contains a perfect flower; the other is pedicellate and narrow, and the flower is either staminate or without the organs of either sex. The terminal sessile spikelets are usually flanked on either side by a pedicelled spikelet. Anthesis in the pedicelled spikelets follows shortly upon the close of the blooming period in the sessile spikelets as though to doubly insure fertilization in the latter. This normally is their only visible function but rarely they do attain a pistillate state, thus becoming fertile and producing seed. This condition among sorghums in India has recently been reported by Ayyangar and Rao,[2] but appears not to have been noted in America until J. B. Sieglinger, working with sorghums at the Southern Great Plains Field Station, Woodward, Oklahoma, observed

in certain of his hybrids in 1935 numerous instances of seed-bearing pedicellate spikelets (Figure 8-*C*). He reported to the writers that the condition was particularly prevalent in F_3 generation material of a feterita × Sudan hybrid where it was observed in 71 of the 134 progenies. Since Sieglinger's observation the writers have examined material and found perfect flowered as well as seed-bearing pedicelled spikelets so that this condition appears to be not so uncommon in America as generally believed. One or both of the stalked spikelets may develop seed; however, they are smaller than the seed from normal seed-bearing sessile spikelets.

Other Abnormalities

Other abnormalities which appear to be the development of extra structures rather than the modification of normal parts have been observed.

Ovaries with three stigmas are not uncommon. Usually the third stigma is located on the palea side of the ovary. In place of a third stigma there may be a small protruding growth which probably is a rudimentary style. The ovary of one blooming flower carried a third stigma on the lemma side and the protuberance on the palea side.

Four stamens are sometimes found when emasculating sorghum flowers. The usual origin of the fourth stamen has not been determined, but in two cases the filament was attached about midway between two of the normal filaments and could not be seen to branch or arise directly from either.

Extra bracts are observed from time to time. In one instance, in an F_2 row of a Red kafir × Freed hybrid, a spikelet was found with a second set of outer glumes within and crosswise to the first set; sterile lemma, fertile lemma, palea, and other parts were within the second set of hard glumes but properly oriented to be considered normal with respect to the first pair of glumes. In an F_2 head of a Dwarf White × Dwarf Yellow milo cross, a spikelet occurred in which a hard bract developed between the lower glume and sterile lemma; other parts of the spikelet were normal and properly located. In another panicle from this cross an awned papery bract appeared between the sterile lemma and palea; other structures in the spikelet were normal, and the location of this awned bract suggests that it may have been the lemma of a third flower.

Such abnormalities are of sporadic occurrence and possibly result from a local disturbance in the normal balance of production or translocation of physico-chemical products.

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A EUGENICS PROGRAM

American Eugenics Society Considers Measures to Correct Adverse Differential Birth Rate

IN recent months two interesting publications have issued from the American Eugenics Society. One of these is a seventeen-page "Program of Eugenics," and the other is a more extended treatise entitled "Tomorrow's Children," under the authorship of Dr. Ellsworth Huntington, president of the Society. The latter publication will be reviewed, we hope, in a subsequent issue of the JOURNAL.

The *Program* discusses at some length the need for a eugenics program, and offers some suggestions for specific approaches to the problem.* Even though we may fear that, in the United States today, some of the reforms suggested may be visionary and impractical, still the *Program* may well represent a turning-point in eugenic thinking in the United States.

The two most revolutionary features of the program are a bold placing of positive eugenics first, and an acceptance of the fact that eugenics must take into consideration human environment as well as human genetics. While it is quite true that degeneracy is widely prevalent in our short-sighted ameliorative civilization, the fact nevertheless remains that we can never hope to produce a better race merely by preventing the reproduction of the unfit. Since eugenics, by the definition of its founder, is a study of the agencies under social control which might affect the inborn qualities of future generations, it is obvious that a practical program of "applied eugenics" must take into consideration both environment and heredity.

The following excerpts show the viewpoint of this interesting document:

> The American Eugenic Society has in the past been concerned mainly with those aspects of the birth rate which affect genetic inheritance. It is now consciously enlarging its interests to include not only the hereditary qualities but also the environmental conditions which should influence size of family in homes of various types.
>
> The present is an opportune time for the reformulation of many social policies. For better or worse, Western Civilization is in a period which is likely to result in profound changes. Whether these changes prove beneficial in the perspective of history will depend in large measure on the extent to which our attempts at social planning take accurately into account the less obvious underlying forces of our social life, not the least of which are our present differential rates of reproduction. * * *
>
> The first aim of a eugenics program must be to develop an intelligent and aroused public opinion. The need for better homes and a better home life is already recognized. What must now be learned is that a disproportionately low birth rate in socially adequate homes, and a disproportionately high birth rate in inadequate homes, is an adverse social force, working against all other efforts to improve society; and that undoubtedly in many cases it is a force opposed to biological improvement as well. Leaders of American thought must be aroused against the continuation of such a condition, and, at the same time, the mental attitudes of the ordinary citizen must be redirected. It is a two-fold problem. * * *
>
> Determining the best means of modifying present social attitudes in regard to the family, and putting these means into effect, are among the most important aims of eugenics.
>
> In considering practical methods of redirecting social attitudes, we cannot neglect the economic factors which may prevent emotional needs from finding expression. People may be brought to realize that adequate economic means do not necessarily supply the best background for the proper rearing of children, and

*A Eugenics Program for the United States, by the Board of Directors of the American Eugenics Society, Inc. Pp. 17. American Eugenics Society, Inc., New Haven, Conn. 1935.

that character, intelligence, and affection can provide a good home for children in the poorest circumstances, where wealth without character cannot. * * *

In the period of selective decline in population which we are now entering, the greatest effort of applied eugenics must be to increase the proportion of large families among people who provide homes fitted for the rearing of children. Birth control and the system of voluntary parenthood affect reproduction mainly by reducing the proportion of large families. The present decline in population is not the result of a change in the average age at marriage, or of a large increase of actual sterility. It is the result of a decline in the proportion of families of more than four children, and an increase in families of one, two, and three children. Although at present rates of death and marriage in this country an average of about three children per surviving married couple would be a sufficient number for replacement, the use of such an average is misleading. In every group some couples are sterile, others are limited in fertility to one or two children, and others, because of illness or for compelling economic or other reasons, will have few or no children. To bring the average up to three, and secure permanent replacement for any population group, a fairly large proportion, about twenty per cent, must have five or more children. In rural areas, such a proportion of large families is frequent. But in the cities where the expense and the physical effort involved in the care of children are both very high, it is only among certain small and relatively well-off groups that a number even approaching twenty per cent of the married couples have a sufficient income to provide a secure living for so large a family without seriously impairing their standard of living. * * *

Economic and environmental conditions are so inter-related with attitudes affecting family life, that further studies of the family are necessary before final proposals can be made. The following are among the suggestions most seriously considered at the present time:

(a) Among all social groups more thought should be given to strengthening the economic position of young couples during their early married life. There is no more vicious system than the so-called American ideal that young people should work up through a period of great self-denial in order to arrive at a complacent maturity—with a minimum of children. The expenses incident to the bearing and rearing of children should be the concern of the whole family group, especially of the parents of the bride and groom. These expenses should be prepared for, as far as possible, by savings in the form of dowry, special types of insurance, and all possible help from parents and relatives.

(b) The condition of farm life, especially in those districts where farm incomes are lowest, should be improved as rapidly as possible in order to retain on the farm a full proportion of the best family stocks. The birth rate among married women in farming communities is at present about double that of married women in the cities. While this wide difference may diminish, it is probable that for a long time to come the farm will continue to be the source from which the otherwise diminishing population of our cities will be replaced. We cannot afford to continue, in any rural districts, those farm conditions which result in inadequate facilities for the training of children, and which may well tend to drive the abler and more ambitious people off the land, leaving the less able to supply, of their own kind, the replacements necessary to make up the shortage in the cities. An important part of the farm program consists in educating public opinion in the cities to the need for maintaining at a high cultural level the rural home from which will come, in each generation, so many of their citizens.

(c) City housing programs should be planned with a view to providing, to a far greater degree than at present, recreational and educational facilities for the proper rearing of children. In our cities as they are now constituted there should be more adequate transportation to residential developments especially adapted to child nurture.

(d) There should be a greater development of nurseries and preschools where, for frequent short intervals, mothers may obtain brief periods of freedom from the constant care required by young children. There would appear to be great possibilities in the organization of cooperative nurseries.

(e) The excellent work now being done by child welfare agencies should be extended at the same time that restriction of further births is urged in the case of inadequate families.

(f) In certain large groups comprising teachers in schools and colleges, ministers, and possibly Government employes, it would appear practical to base salary payments on a scale proportionate to the number of children. Such an arrangement has been in effect for some twenty years among the American staffs of American educational institutions in foreign countries. The introduction of such a basis of pay appears to have been a factor in the relatively high birth rate among these groups. Ultimately, such a system might find its way into industry as well.

(g) In assigning school and college scholarships, the primary factor must, of course, be individual merit, but special attention should be given to qualified students from large families. Substantial benefits might be derived from an increased number of scholarships specially designed to meet this need. Instead of limiting higher fellowships to unmarried students, many more graduate fellowships should be open to those who are married.

(h) Existing income and gift taxes already

contain provisions of some advantage to parents with several children. Such provisions should be so enlarged as to effect, in every income group, a reduction in tax somewhat more related to the actual cost involved in rearing each child to maturity. Such a radical change in present exemptions would not seem unreasonable, in view of the interest of the country as a whole in its future citizens.

* * * *

It would seem a truism that as few children as possible should be brought up in homes where there is a bad physical environment, improper parental care and interest, seriously retarded or handicapped parents, or other factors which make for an unhappy childhood and a poor development of the personality. The large families which often occur in such homes consist usually, after the first two or three, of unwanted children, the product of ignorance or of isolation, or of that hopelessness which is engendered by tenements or slums, whether urban or rural. * * *

Along with these changes in physical conditions, public opinion must be aroused to demand that there should not be large families in homes where the children cannot be given a fair chance to become good citizens. * * *

There is nothing radical about these aims and methods. They are in line with almost every other program of social and human advance. They agree with those which might be put forward by the economist in the search for greater economic security, or by the educator looking for greater cumulative effect in education. * * *

Even a slight change in the present differential birth rate could be of great social and eugenic value. We have already noted that birth control affects reproduction mainly by changing the proportion of couples with large families. A relatively small increase in the proportion of families of five or more children among certain groups, and a relatively small decrease in others, would have a significant effect on present trends. Since desirable eugenic changes may thus be effected through conditions that will actually alter the habits of a relatively small poportion of all married couples, progress in eugenic reform is perhaps not so difficult as it is imagined to be by those who are unacquainted with recent studies. * * *

With each new advance in knowledge, the ideal of a better life on earth, to which all men aspire, points ever more clearly to this need, that the nation's children be well born.

There is no lack of conviction *in the abstract*, that something needs to be done about conserving the inborn physical and mental qualities of the human race. There is less unanimity when we attempt to face concrete problems and decide who shall do the job. The situation is reminiscent of Aesop's cat-belling party—with the difference that the folks who concede the need of applying the bell, have a way of being right out front ready to gobble up those who actually set out to do the job. The mice and the cat seem to be suffering somehow from a perplexing case of mixed identity. Pity the Eugenist! If he *does*, he is "sunk," and if he doesn't, his plight seems even worse, only more so.

If the matter were only of academic interest, or concerned only the future of "island universes," or something equally remote from human affairs, it might be merely amusing. Since it is unfortunately true that civilizations do suffer from fatal cycles of growth and decay, and since we do seem to see inklings of the reason for this in such phenomena as the differential birth rate, this failure to arrive at a sound and effective course of action may well have tragic implications.

This unfortunate state of affairs is due in no small part perhaps to a confusion regarding what different people have in mind when they use the word "eugenics." Galton defined eugenics as "the study of the agencies under social control that may improve or impair the racial qualities of future generations, either physically or mentally." The *study* of such agencies may well represent a legitimate scientific endeavor which is beset with many difficulties, but in which there seem to exist no insurmountable obstacles to arriving at valid scientific conclusions. Eugenics as thus defined would be distinguished from human genetics in that it would combine the genetic discoveries regarding man with statistical, psychological, and other procedures to discover what social expedients might alter birth frequencies of various fractions of the population, etc.

Just as soon as an attempt is made to *apply* these "agencies under social control to alter the inborn qualities of the race" we have something else again. We are dealing now with a very elusive and complicated art—an art that obviously can never be, in emphasis or

presentation, a "laboratory science." In the volume under consideration the word "eugenics" appears to have drifted away from the Galtonian view of "a study." It is taken to mean not the budding science of trying to find out what social forces have an effect on birth rates, but rather to mean that branch of human endeavor which attempts, as yet with no great success, actually to alter human birth rates.

If this meaning of eugenics is to be accepted, it then becomes an art, which is related to human genetics, and to the social sciences (or such parts of them as are at the moment scientific) much as line, form and color are related in a painting, which stands or falls as art on something else than correct perspective (applied optics) and properly compounded paints (applied chemistry), put on canvas in a thoroughly workmanlike manner.

The young science of human genetics in particular, and genetic and biological considerations in general, necessarily form the main background of a eugenic philosophy. Eugenics without such a background would be absurd; nevertheless, that branch of human endeavor which seeks to apply "those agencies under social control which improve the inborn qualities of the human race, both mental and physical" is by definition incapable of being treated as a science any more than politics can be a science.

Confusion of thought regarding this point has undoubtedly been an important factor in the failure of eugenics to take a larger place in human endeavor than has been achieved up to the present time. This is no mere quibble. It is a very significant fact that must be taken into account if eugenics is to perform a useful function in guiding the future of our race. There can be little doubt of the need for intelligent, humane, and constructive eugenic intervention in human affairs, and for that reason any stumbling-blocks to sound eugenic efforts are of great significance.

The methods of the scientist and of the artist are fundamentally different. Science attempts to discover facts and to correlate them into fruitful generalizations. Art attempts to use various media to interpret and give value to human activities and experiences. Sometimes the artist is able to apply in his techniques the facts discovered by the scientist. The effects which artists produce on human thought, feeling, and action are nevertheless often obtained by means which have no scientific basis at the present time. The results of scientific research are of value in proportion as they can be repeated and verified. The "products of art" are intangible and ephemeral and are subject to no such repetition and verification. Artistic endeavor has nevertheless been of tremendous importance in the story of mankind, for frequently it results in giving value and purpose to the lives of great numbers of people. In this way it may lead to action by individuals, groups, and classes, and thus result in racial and cultural change.

The materials of the artist are variable. The author deals with words, and by a curious paradox the effectiveness of his presentation is often in inverse proportion to the number and length of words he uses. The politician, or better, the statesman, uses as his medium the hopes, urges, and aspirations of human beings. Frequently the most effective artistic technique is an oblique approach. The emotional overtones of words and other artistic media are the effective agents in leading to action. He who undertakes to use the emotions of men as his medium of artistic expression is attempting to play the most complicated, the most fickle, and (properly employed) the greatest instrument for artistic expression. The difficulty is that too many would-be performers on such an orchestra of human lives are reminiscent of the hopeful soul who didn't know whether he could play the violin, because he had never tried. The contrast between those who can really play this great instrument and those who fail to make themselves masters of the medium they attempt to employ, is brought into clear focus by

the searching jibe attributed to Demosthenes: "When Aeschines speaks, men say: 'How well he talks.' When I speak, men say: 'Let us march against Phillip!'" There is no middle ground. If eugenics is to serve any useful purpose in the conscious evolution of the race, its votaries must aspire to play a symphony on an instrument made up of the lives and aspirations of men. Most eugenists would be inclined to "hedge", and to take refuge in a hope that "bare facts" will tell a sufficiently compelling story so that by some mysterious magic human beings will become logical in their actions. There seems little likelihood that so fundamental a change is likely to occur. We may well question whether there is any middle course that justifies us in the belief that our efforts on "a purely intellectual plane" are likely to prove fruitful in any visible improvement of the inborn qualities of the race.

It is a truism that human civilizations seem to have inherent in them certain fatal predispositions to decline. The eugenist's view that the key to these fatal cycles of progress and decay is to be found in human hereditary differences is rather better grounded than any of a number of "cultural" explanations. Modern transportation and communication have made the world so small that changes in the constitution of populations may take place in a few generations that in an earlier age would have taken many generations. The fatal effects of an adverse differential birthrate may now change the history of entire races, where formerly only a limited area was affected. It follows almost as an axiom that rightly conceived the conscious effort to enhance the inborn qualities of our descendants (and this means grandchildren as well as great-great-grandchildren) is one of the most compelling problems that confronts us. It is also true that it may represent one of the most satisfying and fascinating activities in which any human being may engage. When we consider the profound effect that the religion of ancestor-worship has had in perpetuating the Chinese civilization, it would seem, in the light of modern biological knowledge, that an enlightened cult of descendant-worship might be even more emotionally satisfying.

Like so many axiomatic propositions, the self-evident importance and fascination of eugenics does not seem to have been as obvious as would appear. No large body of intelligent people are at the moment seriously concerned with the problem. If the premise regarding the racial import of a shrinking world is only fifty per cent correct, it still remains true that few human activities could offer more in sound emotional satisfaction than the practice of this supreme art of learning how we can alter social trends to make our race healthier and happier physically, mentally, and morally than it is at present.

The reviewer does not know whether the authors of the *program* (the Directors of the American Eugenics Society) would be willing to accept the apparently extreme view, that eugenics must develop into a new kind of enlightened statesmanship. The question remains whether a less inclusive view offers any hopeful prospects. Galton looked forward to a day when "Eugenics would sweep the world like a new religion." Under existing government, or under any alternative form of government likely to evolve, it is clear that a movement destined to alter human history must make a compelling emotional appeal to a reasonably large number of people. Mere academic syllogisms are not enough. When we consider the hubbub caused by a wholly impractical chimera such as the Townsend plan, we realize that even with a microscopic basis of fact, it is possible to obtain a following large enough to alarm our "legislative leaders", and to threaten political action. When we take stock of the tremendous emotional appeal potentially to be found in thinking racially forward, instead of racially backward, we are astonished that so little progress has been made. We must conclude that a failure to encompass

eugenic reform would have to be charged by the historian of the future to a lack of intelligent imagination on the part of those whose intellectual background should enable them to evaluate the emergency that confonts us and to invent workable and adequate social adaptations to meet it. Conscious use of the inventive faculty in the solution of social problems represents a real "mutation" in human affairs. Let us hope that the historian of 2136 will be able to report that we had the vision to meet this supreme challenge to our intelligence!

If there were in practice any serious question as to the possibility that we could safely ignore the "factors under social control which affect the inborn qualities of human beings" there would be much point in giving careful consideration to whether we should take the very considerable risk of embarking on a program of eugenics. As a matter of fact, almost everything we do has some more or less indirect effect on the kind of people who will be born and on the age at which they are likely to die. When we consider that the population of Europe increased some six times in the Nineteenth Century in response to factors that few people thought would affect birth and death rates, it is obvious that the things that happen to society are of vital importance to the eugenist. As is vividly brought out in the charts of migration trends recently published in the JOURNAL, the automobile has undoubtedly been a most potent factor in changing the type of living of a large part of our population. The radio, magazines, moving pictures, and all of the other elements of our civilization undoubtedly affect to a greater or lesser extent the birth trends of various fractions of our population. Thus we must face the alternatives of trying to make an intelligent study of these factors, or of throwing our intelligence overboard and leaving the determination of the future constitution of our race to chance, to ignorance, or to the casual stupidity of a commercial or political system. There seems to be no escape from this dilemma. Whether we like it or not it looks as though we would have to decide whether we are content to be racial ostriches or whether we have the courage and the intelligence to try to study and *to apply fruitfully* the forces which are determining the future of our race.

Dr. Lush shows elsewhere in this issue (P. 202) that except in the simplest situations exact knowledge regarding individual genes is of little value in a practical breeding program. If this is true where matings are absolutely controlled, the same reasoning holds even more strongly in eugenics. It is certain that such important human characteristics as intelligence, good bodily structure, altruism, and acquisitiveness depend for their expression on the presence of a large number of genes (as well as on a multitude of environmental factors). If Lush's view is correct, it follows that the problem of conserving our genetic heritage will not be simplified if we wait for more detailed genetic knowledge. A eugenic program must be so broad in its viewpoint that dominance or recessiveness of individual genes will not alter the general picture to any significant extent. If we build our groundwork aright, further knowledge regarding human genetics will not materially alter the picture. If something is lacking, without which it is impossible to embark on a sound eugenic program at this time it is the inspired intelligence to apply principles now well known in a manner which can be relied on to conserve the best in our biological and cultural inheritance. It is not likely that genetics will be able to produce discoveries which will ever resolve this major problem, and make possible a foolproof formula for the eugenic salvation of the race.

What this view really amounts to in the long run is that eugenics probably will have to cry in the wilderness until the essential man or men appear on the scene. Invention involves the utilization of new and hitherto not applied principles and expedients. The problem of eugenics is a challenge in social

invention. Even though a new principle in social evolution may emerge without the crystallizing influence of a vital personality, it is probable that the great advances mankind will make in the future will center around unique individuals as has been true in the past. We can hardly hope that a committee appointed under the by-laws of even the most enlightened organization, or brought into being by legislative fiat, will supplant the essential personality of a Christ or a Lincoln. The eugenist can very consistently subscribe to the urgent need for a Messiah of the human germ plasm. ROBERT COOK

GENETICS AND ANIMAL BREEDING*

THIS twentieth in the series of handbooks on genetic science essentially is three things: an explanation (largely addressed to the geneticists) of what animal breeding is and of how it differs from genetics, a rather detailed review of what has so far been reported in a Mendelian way about the genetics of the various kinds of farm animals, and a discussion of the kinds of work most likely to be fruitful in the future.

Animal breeding is an old industry; genetics is a young science. The old industry had built its own empirical rules of procedure out of centuries of casual observation and often expensive trial and error. It may be timely and worthwhile to inquire, as is done here, how the procedure of the industry has already been, is being now, or is apt to be modified by the science. It is doubtless true that the art of animal breeding had reached greater empirical heights than the corresponding art of plant breeding in pre-Mendelian days and (partly because of this?) has not yet been changed as much by the science of genetics as plant breeding has. Professor Kronacher's historical account of the development of animal breeding in the pre-Mendelian and early post-Mendelian days will be enlightening to many, even among those who are already well informed about animal breeding.

The account of what has already been reported about Mendelism among the farm animals is one of the most valuable features of the book, especially to those actively working in the field of animal breeding. Its extensiveness is best witnessed by the list of literature which occupies 89 closely printed pages.

The discussion of the kind of work which will prove most fruitful in the future will of course meet the most disagreement since by its very nature it has to venture somewhat into prophecy. Especially stressed are: more Mendelian analysis, research on twins, research on the chemical and physical properties of blood and on the nature and activities of hormones, the analysis of herdbook information, and the collection and analysis of cases reported here and there from breeding practice. The necessity for cooperation both with breeders and between institutions is stressed. He is convinced that genetic studies started on material found in the herds of practical breeders for final and accurate analysis and for test matings usually needs to be studied at research institutions especially planned and equipped for that purpose.

In many places it is stated or implied that the breeder's task will be vastly easier once he has a Mendelian list of the genes involved and knows which are dominant and what their linkage relations are. Accompanying this is naturally some overstressing of the importance of dominance and of homozygosis. Part of this naturally flows from the assumption that the number of important genes

* C. KRONACHER. Genetik und Tierzüchtung. Pp. 280. 61 illustrations and charts. Lieferung 20, Handbuch der Vererbungswissenschaft. Gebrüder Borntraeger, Berlin, 1934.

affecting each characteristic is very small. (The work on salivary gland chromosomes with its bearing on the probable number of loci was just starting to appear in print when Professor Kronacher wrote.) How would the author (and those who hold similar views) advise the breeder to proceed even if he had perfect knowledge of the genes and their inter-relations but if there were 10 or 20 or more pairs of genes affecting each important characteristic? In short, the reviewer would like to see this reasoning extended to *n* genes to see whether such knowledge about the individual genes would after all be very useful, since in their segregations and recombinations the genes would be obeying the laws of Mendelism which automatically result in an offspring population which is distributed nearly like the square of the ratio among the gametes from its parents. That gametic ratio itself is something like a binomial raised to the *nth* power. From this it seems to follow that as soon as we embark on a breeding program dealing with anything except characters inherited in the simplest manner, such as color, the problem becomes too complex to keep track of single genes. In actual practice plant breeders have used knowledge of general Mendelian principles to help them choose this or that breeding system or procedure but have rarely known or been able to use the exact Mendelian formula of the individual plants with which they worked.

Professor Kronacher's enthusiasm for the von Patow hypothesis of the genetics of milk and fat production in dairy cattle and for the genetics of twinning in sheep leaves the reviewer cold and skeptical that those hypotheses have either advanced the science of genetics or been useful in the business of practical breeding. The expression of yields as a percentage of the average yield of a large herd automatically gives a distribution of figures which averages not far from 100 and has somewhere near a normal distribution. The demonstration that such a distribution can be described at least roughly by the curve of $p + q$ to the sixth power where p and q each equal ½ seems to prove very little. Neither do the so-called critical test matings of the sire to certain kinds of cows in the extreme classes seem to the reviewer to mean anything, since those matings are in fact critical test matings only upon the assumption that the working hypothesis is correct. It seems to the reviewer altogether likely that we in America could with advantage make more use of the "stalldurchschnitt" or "byre average" than we have yet done in our practical breeding selections. (This practice rests on the assumption that differences between herd averages and between annual averages are entirely matters of environment and management, whereas the practice of using actual records without paying attention to the herd or year in which they were made infers that differences in herd or year averages are entirely genetic. Of course the truth is somewhere in between—but just *how far* is it from each extreme, in each particular set of data?) It seems unlikely that the von Patow method can ever lead to a Mendelian analysis which corresponds at all to reality except in so far as both it and the reality can be described at least roughly by something like a normal curve. Among the other shaky premises on which the method rests is the hypothesis that p and q will always equal ½ if the herd is large enough. Why should that happen in the first place? What would keep them at that value over a period of years when some individual selection for high production was taking place? How much of the variation in the curve is from more or less random environmental causes? Just what is done by excluding from the computations all lactations which are considered "abnormal"? In actual practice the method leads to the same result as a sire index capable of dividing the population into only seven classes from highest to lowest producers, except that more weight is given here than in most indexes to

the results of mating sires with extremely high or extremely low producers and correspondingly less attention is given to the results of matings with average females.

The method also permits some inferences about the comparative homozygosity of sires in certain of the intermediate classes, but this is of little practical use, even if those inferences are sound. The progeny *averages* of sires belonging to the same intermediate class would be alike, the only difference being that the progeny of the more heterozygous ones,—e.g., *AABbCc* as contrasted with *AABBcc* or *AAbbCC*,—would be *more variable* in both directions from that average.

Incidental mention should be made of the inference that the great heterozygosity of many livestock breeds is the result of their having been produced by crossing other breeds or races which (by inference) were homozygous or nearly so. Perhaps this is only an unconscious hangover from the Linnean idea of fixity of species—a hangover which still crops out frequently in all kinds of modern biological writings. The point is illustrated by the sentence on page 71 where we read (of swine): "Vor allem sind aber unsere Kulturrassen das Ergebnis zahlreicher und verschiedenster Kreuzungen und Einkreuzungen, so dass auch die Vertreter zeit längerer Zeit 'reingezüchteter' Kulturrassen und Stämme sich in zahlreichen Merkmalen als heterozygot erweisen und in ihrer Erbkonstitution häufig schwer zu erfassen sind, um so mehr, als naheliegenderweise Kreuzungen ganz gleicher Art nicht selten recht verschiedene Ergebnisse bringen."* How did an ancient breed or race or a wild species come to be homozygous in the first place? or heterozygous? And in what way do the forces which made it homozygous or heterozygous in its particular degree differ from the forces which tend to do the same thing for the present domestic breeds? The myth of ancient purity of breeds or races dies hard, if indeed it dies at all.

The section on breeding for disease resistance is excellent in detailing some of the precautions needed in such research and the considerations which may help or hinder the application of these research findings to animal breeding practice.

There is only scanty appreciation of the rôle which might be played in livestock breeding by inbreeding. It seems to be considered mainly an aid to Mendelian analysis and cataloguing, rather than for its family-forming power and its ability to help in getting around the effects of epistatic gene interactions.

Finally there is repeated at many places the assertion that statistical investigations ("Massenstatistische Untersuchungen") lead nowhere and are of little or no practical benefit. That is an opinion also held by others, to be sure, but surely the reader is entitled to be told when and how this was proved, especially when its futility is contrasted with the supposed fruitfulness of the superficially Mendelian methods.

These criticisms are of minor importance after all. The book remains an excellent explanation of animal breeding to geneticists, an extensive compilation of the genetic work already done on farm animals, and a statement of the present and future relations between animal breeding and genetics and of the paths in which animal breeding research may most profitably go, as seen by one who for more than three decades has been most active in trying to keep animal breeding in step with modern genetics.

JAY L. LUSH

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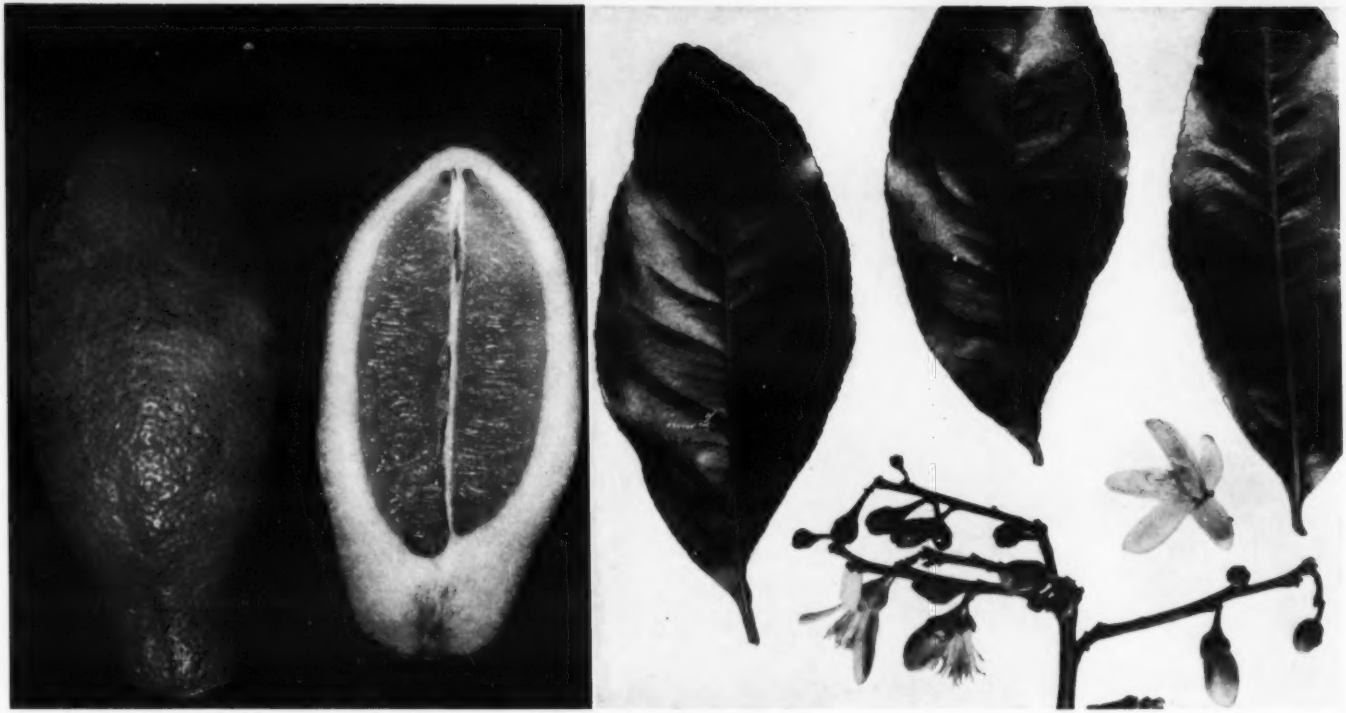
Translation: "First of all our improved races result from numerous and highly complex crossings and re-crossings so that even the representatives of races and breeds "bred pure" for a long time prove to be heterozygous in numerous characteristics and frequently it is difficult to make out their hereditary factors, especially when other but similar crosses sometimes give widely different results."



A CITRUS MUTATION?

Figure 9

Fruit, leaves and blossoms of a citrus rootstock showing peculiar characteristics not recognized in the lemon varieties grown ordinarily in California or Florida. The illustrations are only about half size, and the large fruit with a distinct neck is very different from the ordinary small round fruits. Its resemblance is noted to a Mediterranean variety of lemon. Whether it has arisen "de novo" or represents some forgotten importation many years ago is not clear.

AN UNUSUAL CITRUS ROOTSTOCK

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IN the autumn of 1927, Mr. Edgar W. Stow, a citrus grower, called the writer's attention to a lemon orchard in which the rootstock variety seemed of interest. This orchard, which is located in Santa Barbara County, consists of about seven acres. According to Mr. A. J. Haverland, who purchased the orchard in 1896, the trees were shipped from Florida in 1894. The shipment, so the story goes, was held up in transit owing to a railroad strike, and when the trees finally arrived they were "buried for about a week to revive them" and then planted and whitewashed.

The scion variety is of the Eureka lemon type, but as is usual in most orchards, there is some variation. Up to about 1930 the trees were in excellent condition and very profitable; since then they have gradually declined but still bear profitable crops.

The interesting feature in this orchard, however, is the fact that most of the trees are on lemon rootstock. To the writer's knowledge, this species as a rootstock has not been hitherto observed or reported as occurring in old citrus orchards in California.

Through the cooperation of Mr. Haverland, rootstock sprouts were allowed to develop and about two dozen sprouts were examined. All of them were of the Libson or Villafranca type except one which was so different that it was thought worth while to propagate it. Accordingly, the sprout was divided into three cuttings which were rooted and finally planted in the orchard in 1931.

Figure 9 shows representative leaves and blossoms. In comparison with the commercial lemon varieties, the leaves are rather long and narrow. The average length-width ratio of a hundred leaves was 2.3, as compared with 1.9 and 2.0 for leaves of the Eureka and Lisbon lemons respectively.

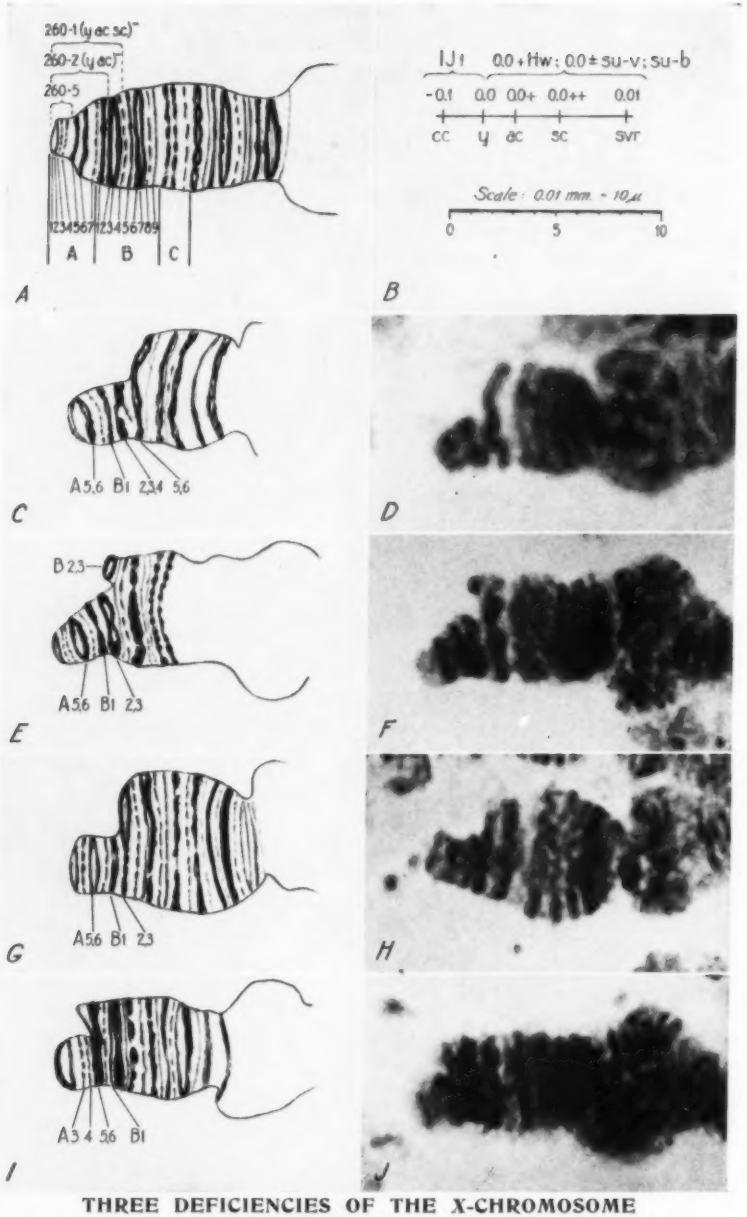
The trees began to bear fruit in 1934 and up to September, 1935, about 60 fruits had been examined. One feature which distinguishes this fruit from the commercial lemon is its shape. While the fruits varied considerably in shape, the type shown in Figure 9 is representative. The length-width ratio is about 2.1, while in the case of the Eureka and Lisbon fruits, the ratio is approximately 1.4. Near the stem-end there is a constriction which, in a few cases, is very pronounced. The juice content seems to be normal.*

Another outstanding feature is that none of the fruits contained seeds; however, this cannot be considered a definite characteristic until several successive crops have been examined.

Summary

Attention is directed to a commercial lemon orchard in which the majority of the trees are on lemon rootstock. About two dozen rootstock sprouts found resembled the Lisbon or Villafranca variety, except one which proved to be an unusual type and possibly a new variety of lemon.

*After examination of both trees and fruit, Professor Robert W. Hodgson of the Division of Subtropical Horticulture, University of California, Los Angeles, reports that this lemon is remarkably similar to, if not identical with, a variety he observed in both Sicily and Tunisia and which in the latter country is known as "le citron de quatre saisons" (everbearing lemon).



THREE DEFICIENCIES OF THE X-CHROMOSOME

Figure 10

A—Diagrammatic drawing of the left hand tip of the *X*-chromosome as seen in salivary glands. Limits of three deficiencies are indicated. *B*—Genetic map of the same region of the chromosome. *C* and *D*—Drawing and a photograph of the *(y ac sc)⁻/dl-49, y Hw* deficiency which involves the first 10 to 11 bands shown in *A*. This deficiency when homozygous is lethal to the whole organism and is also "cell lethal," "islands" of deficient tissue in normal tissue not being viable. Death occurs in the egg stage of development. *E, F, G* and *H*—Drawings and photographs of the *(y ac)⁻/dl-49, y Hw* deficiency involving eight bands. This deficiency is lethal to the whole organism but is not "cell lethal." Death occurs partly in the egg stage and partly in the early larval stage. *I* and *J*—Drawing and photograph of *260-5/dl-49, y Hw* deficiency which involves only the first four bands. This deficiency is not lethal. Its only noticeable effect is at decreased fertility of females homozygous for it.

THREE RELATED X-CHROMOSOME DEFICIENCIES IN DROSOPHILA

Differing in Extent of Deleted Material, and in Viability

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PAINTER'S[8] discovery that the structure of salivary chromosomes can be correlated with the structure worked out by genetic methods makes possible the positive identification of the limits of deficiencies. Bridges' careful maps[1] of details of the salivary chromosome structure made under optimal conditions, both optical and cytological, facilitate greatly the cytological analysis, and the reference system proposed by him helps toward the general understanding of the results. Both of these findings opened up a new field in cytogenetic research with Drosophila and both have been utilized in the work described below.

In this paper reference will be made to three deficiencies involving regions of the left hand tip of the X-chromosome. As these deficiencies became available, they were numbered 260-1, 260-2, and 260-5. These numbers will be used here for convenience.*

Origin

The deficiency called 260-1 was obtained from Mrs. L. V. Morgan in the summer of 1932 and presumably originated under natural conditions at the Pasadena laboratory. It is the same *y ac sc* deficiency as was used by Ephrussi[4] and referred to by him as Def. 100. This deficiency was also used by Stern.[10]

Deficiency 260-2 was found in November of 1933 in an X-ray experiment in which a treated bar male was mated to a *yellow, scute, vermilion, miniature, forked* female. The original female carrying the deficiency was yellow but was not scute, indicating that the *scute* locus was not included in the deficiency.

Deficiency 260-5 was found while chromosome studies were being made of the salivary gland preparations of another deficiency obtained through X-rays. It is probable that these two deficiencies originated simultaneously.

Genetic Length

Genetic tests indicate that 260-1 is deficient for *y ac* and *sc* loci, and that it is not deficient for the locus *svr*. Line 260-2 is deficient for *y* and *ac* loci but is not deficient for the *sc* locus; deficiency 260-5 does not extend even to the locus *y* which is the first visible extant locus from the left hand tip of the *X*-chromosome.

Cytological Length

In the salivary chromosome study of a deficiency it is essential to have a good picture of the normal condition of the region of the chromosome under investigation. In order to be able to refer to the various lines, it is also essential to have a system of nomenclature. Bridges' salivary maps[1] and his reference system satisfy both of these requirements. Additional lines discovered through intensive study of a certain region do not affect the main reference system which divides chromosomes into large sections indicated by numbers and each of these into smaller

*The following symbols will be used throughout this paper: + = wild type; ˉ = deficiency; *ac* = achaete; *cc* = chlorotic; *df* = deficiency; *dl-49* = delta-49 inversion; *Hw* = hairy-wing; *lJ1* = lethal-J1; *M* = minute; *sc* = scute; *sn* = signed; *su-b* = suppressor of black; *su-v* = suppressor of vermilion and sable; *svr* = silver; *y* = yellow.

sections indicated by letters. The discovery of additional lines will change only the number of lines in the small section.

In making this study two lines which have been drawn by Bridges as single lines were found to be double. Figure 10*A* is a diagrammatic drawing of the normal left hand end of the *X*-chromosome. In counting lines each double line is counted as two singles. The lines *1B2* and *3* and *1B6* and *7* were marked as single lines by Bridges. On Figure 10, *E* and *F* it can be seen that in each of these two cases two lines are present.

Microscopic examination of salivary chromosome preparations shows that all three of these deficiencies are terminal, involving a loss of the extreme end of the chromosome. A large number of good figures was examined for each of them, and in no case was there any indication that the section missing from the tip end was transferred to some other region of the chromosomal complex. Since in salivary chromosomes there is a very strong tendency for homologous bands to synapse, a translocation of even such small sections of the chromosome as investigated here would have been expected to produce configurations characteristic for translocations.

All our deficiencies were studied in the heterozygous condition. In salivary glands both members of a pair of chromosomes are so tightly glued together as to form what appears to be a unit. If certain bands are missing from one member of the pair, the full complement of these same bands in the other member of the pair serves as a marker for identifying the deficiency. Hence a study of the heterozygous condition is the most dependable method for investigating deficiencies. In the material heterozygous for a terminal deficiency the tip of the deficient chromosome appears to be chipped off.

In the material heterozygous for 260-1 deficiency (Figure 10, *C* and *D*), which involves *y ac sc* loci, all bands of the section *1A* are missing and in the section *1B* bands 1, 2, 3 and probably 4 are deficient. Band *1B4* is a faint broken line which makes it difficult to determine whether or not it is deficient. The deficiency, therefore, involves at least 10 or 11 bands.

In the material heterozygous for 260-2 deficiency (Figure 10, *E*, *F*, *G* and *H*), which involves *y* and *ac* loci, the last deficient band is *1B1*. The first band that is not deficient is *1B2* which can be seen as a part of a heavy double band capsule. Figure 10 *E* and *F*, show also a short split at the tip of the chromosome involving *1B2* and *3* bands only. Such a split extending sometimes for a few bands is common in the 260-2 material. A characteristic feature of this split is its tapering appearance. In the deficient half of the chromosome, bands *1B2* and *3* are at the tip and are narrower than the homologous bands in the normal half. This deficiency involves at least 8 bands.

The deficiency 260-5 which does not involve any of the known extant loci includes at least 4 terminal bands of the X-chromosome as shown on Figure 10 *I* and *J*.

Viability Tests

Both 260-1 and 260-2 are lethal to the whole organism. In none of the numerous experiments conducted with these two deficiencies did any deficient males appear.

The 260-5 deficiency, however, is viable in both males and females. The flies of both sexes have a normal wild-type phenotype and good viability. The fertility is good in males but is somewhat reduced in females.

"Cell lethal" tests with (*y ac sc*)-260-1 indicate that in females this deficiency is lethal to a small group of hypodermal cells. The method worked out by Stern and used in these tests has been previously described.[2, 10] The procedure is as follows: somatic segregation of marked *X*-chromosomes of females was stimulated by the presence of an autosomal *minute* factor and thus frequent twin patches were obtained, one representing the cell lineage of a

cell receiving one member of the *X*-chromosome pair and the other patch representing the cell lineage of the cell receiving the other member of the pair. On females of the constitution (*y ac sc*)$^-$ 260-1/*sn*; *M*/+ only singed patches appeared, indicating that the 260-1 deficiency is lethal to even a small group of hypodermal cells of females. The same experiment was performed on a much larger scale by Stern[10] who found that sometimes single setae homozygous for the deficiency appeared. Ephrussi[4] by using an entirely different method to produce mosaic patches found that on males small patches of hypodermal cells homozygous for the deficiency are able to exist. This suggests that there is a difference in the behavior of hypodermal tissue in males and females as far as the cell-lethal effect of this deficiency is concerned.

In the case of the (*y ac*)$^-$ 260-2 deficiency, somatic segregation produced twin patches (yellow and singed) showing that this deficiency is not "cell-lethal," and that in females small patches of hypodermal cells homozygous for the deficiency were able to live. The deficient patches were just as large and as frequent as non-deficient patches. They carried normal looking setae. This observation was made in February, 1934, but not much weight was given to this finding since at that time conclusive evidence was lacking to prove that 260-2 was really a deficiency. As pointed out at another place,[3] these results could have been interpreted by assuming that 260-2 carried a lethal allel of *yellow*. Salivary chromosome studies, however, showed that 260-2 is really a deficiency.

Experiments were performed to determine approximately the stage of ontogeny at which (*y ac sc*)$^-$ 260-1 and (*y ac*)$^-$ 260-2 showed a lethal effect. For this purpose counts of eggs, larvae, pupae, and flies were made. Both deficiencies were studied in cultures where females were *df/dl-49, y Hw* and males were *dl-49, y Hw*. For controls, cultures of *rux/dl-49, y Hw* × *dl-49, y Hw* were used. In these matings one half of the females are expected to be *df/dl-49, y Hw* in tests or *rux/dl-49, y Hw* in controls, and they should have good viability. The other half of the females are expected to be *dl-49, y Hw/dl-49, y Hw* which usually died in the late pupal stage. One half of the males are expected to have good viability since they are of *dl-49, y Hw* constitution; the other half of the males in controls should also have good viability, but in the deficiency cultures they are not expected to appear since they have a lethal genotype. The deficiency cultures, therefore, should have 25 per cent fewer pupae than controls since these individuals die at some stage of ontogeny. Counts of eggs, larvae, and pupae should show when this death occurs. Table I summarizes the results. This table indicates that all, or at least that a great majority, of the (*y ac sc*)$^-$ 260-1 deficient males die in the egg stage. The data also show that not all (*y ac*)$^-$ 260-2 deficient males die in the egg stage but that some of them hatch into larvae.

To determine more exactly the time of death of the individuals carrying the (*y ac*)$^-$ 260-2 deficiency, a set of 101 eggs was transferred to small watch glasses filled with Pearl's transparent, synthetic culture medium and the larvae were observed every 12 hours. Out of 101 eggs, 27.7 per cent did not hatch. Out of 73 larvae, 14 died before pupation, most of the deaths occurring before the end of 4.5 days after egg laying and all deaths occurring before 5.5 days after egg laying. These cultures were raised at 22° C. and the larval period lasted up to 10.5 days after egg laying. This indicates that when the death of (*y ac*)$^-$ 260-2 deficient males occurs in the larval stage, it must occur during the early larval development.

Gene Loci and Chromosomal Bands

Cytogenetic evidence available at present indicates that genetic loci are closely correlated with the bands on salivary chromosomes. Although unquestionable proof is not as yet available, it appears probable that a single band marks the

locus of a gene. The possibility is not excluded, however, that the position of genes is between the bands, in which case a band would be a product of the activity of two adjacent loci. Whatever may be the true condition, the absence of a locus would result either in the absence of a band or in a change in a band, and the absence of several loci would produce the absence of one or more bands.

Cytogenetic evidence obtained in this study makes it possible to determine the position of a number of loci within the limits of a few bands. Figure 10 *B* shows the genetic chromosome map of the tip region of the *X*-chromosome. The order of *cc, y, ac, sc,* and *svr* loci is well established. Unfortunately the material representing the *cc* locus has been lost, so it is not possible at present to make tests with that locus. The locus *Hw* is known to be near *y,* but it is not known what its position is in relation to *y, ac,* and *sc* genes. Both (*y ac sc*)$^-$ 260-1 and (*y ac*)$^-$ 260-2 were tested with *Hw* and in both cases the *df/Hw* phenotype is simular to the +/*Hw* phenotype. This gives no indication as to whether *Hw* is included in any of these deficiencies, since, as has been stated by Muller,[5] the hairy wing phenotype depends on the number of *Hw* genes present and is not influenced by the presence of wild-type allels. If that is true, then it would be expected that a deficiency for *Hw* would not influence the *Hw/df* phenotype and consequently a genetic test is lacking by which a *Hw* deficiency can be detected. According to Muller[6] *lJ1* is located to the left of *yellow.*

The 260-5 deficiency involves the four end bands shown on Figure 10 *A.* Since flies with this deficiency have perfect viability, the *lJ1* locus must be to the right of these four bands. The deficiency (*y ac*)$^-$ 260-2 involves four additional bands which were not deficient in 260-5. Among these four bands are those corresponding to the *lJ1, y,* and *ac* loci. Finally, the (*y ac sc*)$^-$ 260-1 involves three additional bands among which is that corresponding to the *sc* locus.

This same region of the *X*-chromosome has been studied by Muller and Prokofyeva.[7] On the drawings published in their paper, however, so many bands have been omitted that a dependable comparison with the drawings published here is not feasible.

Importance of Loci to the Organism

The material described in this paper contains evidence of how different deficiencies may affect vital functions of a developing organism with lethal effects of varying degrees.

The homozygous deficiency of four terminal bands (260-5) has a very slight effect on the organism. Under ordinary culture conditions it does not affect the phenotype of either males or females. Neither does it affect the viability of flies. The only noticeable effect of this deficiency is a decrease in the fertility of females.

A terminal deficiency (260-2), which in addition to these four bands, involves the neighboring four as well, is lethal when homozygous to the organism as a whole, but is not lethal to a small patch of hypodermal cells surrounded by cells not homozygous for the deficiency. During the ontogenetic development in cultures raised at 22° C. the lethal effect takes place partly in the egg stage and partly in the early larval stage.

A homozygous deficiency (260-1) which involves eleven terminal bands is not only lethal to the whole organism but also prevents the development of

TABLE I. Counts of eggs, larvae, and pupae showing the death rate at these stages of development.

	Eggs			*Larvae*			
		Dead			*Dead*		
Culture	*Laid*	*Number*	*Per cent*	*Hatched*	*Number*	*Per cent*	*Pupae*
(*y ac sc*)$^-$ 260-1	817	217	26.7	600	37	6.1	563
(*y ac*)$^-$ 260-2	1,112	189	16.9	923	182	19.7	769
Control	597	44	7.3	553	69	12.4	484

small patches of hypodermal cells growing as "islands" in normal tissue, as tests on females showed. In the ontogenetic development the lethal effect takes place in the egg stage.

The intensified injurious effect of the (*y ac*)$^-$ *260-2* deficiency and particularly of (*y ac sc*)$^-$ *260-1* deficiency may be either due to the cumulative action of injurious effects of the absence of a larger number of loci, or it may be due to the fact that in the *1A5* to *1B1* section of the chromosome which is common to them both there is a locus of vital importance to the organism. That this locus is neither *y* nor *ac* is evident, since it has been shown by Muller[6] that males deficient for both *y* and *ac* are viable. If there is any essential locus in that region, that locus must be *1J1*, which is, according to Muller, a lethal. That the lethal effect of a deficiency is not entirely correlated with its size is indicated by the fact that we have one deficiency in the *forked* region and another one in the *facet* region each of which in spite of involving two or three bands only has a "cell lethal" effect. These considerations would indicate that every locus is not of equal importance in the vital processes of an organism.

Miscellaneous Observations

The *ac* character is exaggerated by the deficiency. In an experiment in which the right side of the thorax of 50 *y ac*/*y ac* females was examined, in 74 per cent of flies the anterior dorsocentral bristles were missing, in 98 per cent of flies a few macrochaetae were missing, and in two per cent of flies many macrochaetae were absent, while an examination of the same number of (*y ac*)$^-$ *260-2*/*y ac* females showed that 92 per cent lacked anterior dorsocentrals, 42 per cent had a few macrochaetae missing, and 58 per cent had many macrochaetae missing.

On females of the constitution (*y ac*)$^-$ *260-2*/*sn*; *M*/ + twin spots are frequently found, one of which has yellow setae and carries the chromosome deficient for *yellow* and the other has singed setae and carries the *sn* chromosome. This indicates that the nullo-*yellow* genotype produces a yellow phenotype as has been already pointed out by Ephrussi[4] and later by Muller.[5] The yellow color of nullo-*yellow* on patches obtained on (*y ac*)$^-$ *260-2*/*sn* females was compared with the color of the *yellow-1* allel as it appears on patches on *y Hw*/*sn* females. It has been found that these two yellows are so similar that they can not be distinguished. Also a comparison of the yellow color of a nullo-*yellow* patch and of a *y Hw* male did not reveal any significant difference between the two. This suggests the possibility that some characters which are now being considered as determined by a change in the gene may really be due to viable deficiencies as has been suggested by Stadler.[9] The existence of several allels in the same locus, however, makes improbable the supposition that deficiencies are generally responsible for the appearance of various characteristics.

Summary

The deficiency *260-1* involving *yellow*, *achaete*, and *scute* loci, cytologically involves a section of at least ten salivary chromosome bands at the tip end of the *X*-chromosome. In homozygous condition this deficiency is lethal to the whole organism and is also "cell lethal" in females, viz., lethal to a small patch of hypodermal cells.

The deficiency *260-2* involving the *yellow* and *achaete* loci, cytologically takes a section of at least eight bands at the tip end of the *X*-chromosome. In homozygous condition this deficiency is lethal to the whole organism, but it is not "cell lethal."

The deficiency *260-5* does not involve any of the visible extant loci. It takes a section of at least four bands at the tip end of the *X*-chromosome. Flies homozygous for this deficiency are viable and fertile. They do not show any visible peculiarities. The only detectable effect of the deficiency is a decrease in the fertility of females.

The loci *lJ1*, *y*, and *ac* are placed in a section of the chromosome represented on the drawing on Figure 10 *A* by four salivary chromosome bands (*1A5*, *6*, *7* and *B1*), and the locus *sc* is placed in a section represented by three bands (*1B2*, *3* and *4*).

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BILATERAL ASYMMETRY IN FRECKLING

THE subject is a young man. When about three years of age a black spot appeared on the right cheek just above the lower jaw. This spot is still present. Around it appeared freckles which have spread until now they extend out over the cheek, temple, forehead and nose, being most pronounced about the right eye. A distinct line is formed, running exactly down the center of the forehead and nose. These freckles are large and coalesce, forming a permanent pigmentation with but few areas of unpigmented skin within it. None of these permanent freckles are found left of the median line, but under certain conditions of wind and sunshine freckles come on the left side; they disappear, however, when these conditions are removed.

The young man's hair is dark brown. His skin, which is thin and transparent, is easily irritated by dust, soap, and other such material; it sunburns readily but never tans. In these respects he resembles his father, who was born in England. The mother is a native American of Scotch-Irish nacestry. In so far as he knows, this pecularity has never appeared in his ancestry.

Paul M. Adams
Intermountain Union College, Helena, Montana

WHAT IS A "BASIC PLANT PATENT"?

To the Editor of the Journal of Heredity:

I was very much interested in going over the article by Eyster and Burpee on doubleness in the nasturtium. The appearance of this type of flower is of great interest to florists. I am wondering about the general question of the application of patents to variations of this kind. It is noted on page 59, for instance, that a basic patent has been granted upon doubleness in the nasturtium, a basic patent being defined as one which applies to an invention in all of its known ramifications. I am wondering if we are not going too far in cases of this kind, because doubleness is an old story in flowers. It seems to me that it would be just as logical to take out a basic patent on the idea of a color sport in the apple. I wonder how this patent would stand the test in court. All that was intended, as I understand the law, was to protect the propagation rights of a new or distinct plant entity. You have pointed out some of the inconsistencies in the patent laws as applied. I believe that one can almost infer from some of the early patents that the process of fertilization is almost included in some of them. It would be possible to arrive at the double condition in the nasturtium from other angles than in this instance, but according to the way this patent seems to have been set up, that would be considered an infringement.

I should very much appreciate getting your reaction on this particular patent because there is nothing new in the invention of doubleness in the nasturtium, since that has been known in other flowers for a long time.

M. J. Dorsey,
Chief in Pomology.

College of Agriculture,
Urbana, Illinois, March 20, 1936.

The question of what legal principles apply in the matter of basic plant patents remains to be decided by the courts. Until some of these points are tested by court decisions, one view as to these matters may be as good as another. Possibly the authors are correct in the statement that "A basic patent is one which applies to an invention in all its known modifications. This patent is basic in *Tropaeolum* in that it covers the extreme doubleness of the flowers in all of the colors that are known to occur in *Tropaeolum majus.*" Until this view has received the sanction of the courts, it must be accepted only as the opinion of the authors of the article, and not as a valid statement of law. The following comments are also emphatically of the same character. The writer has submitted them to two patent attorneys, who feel that the views expressed do not do violence to the technical patent concepts. The views expressed are nevertheless purely in the nature of personal opinions.*

The "Claim" Dilemma

The question of basic plant patents would seem to hinge on a number of perhaps somewhat conflicting concepts with regard to plant and mechanical patents. The patent laws require that the inventor ". . . shall particularly point out and distinctly claim the part, improvement, or combination which he claims as his invention or discovery". In the patent specification the description of the device patented is followed by brief summary statements called "claims" whose purpose is to comply with this feature of the law. These claims are the most important part of the patent in infringement suits to delimit the extent to which an invention is protected by patent, which is the usual way to determine how "basic" it is. The inventor and his agents before the Patent Office attempt to obtain claims as "broad" as possible. The Patent Office attempts to make certain that the claims alleged are contained in the patent specifications so that the public will not be imposed upon. The number of claims which an inventor may advance is not limited, (though he is charged at the rate of $1.00 per claim for all over twenty). Often in cases of litigation the courts hold a "broad" claim invalid, but uphold one or more of the

* The reader is referred to that most excellent discussion of patent law as relating to plant patents—"The First Plant Patents"—by Robert Starr Allyn. Pp. 110, illus of first 84 plant patents. Educational Foundations, Inc., Brooklyn, N. Y.

less broad claims which may give very valuable protection. Thus from the inventor's point of view, in a multiplicity of claims there is safety.

A basic patent involves the utilization of a new idea or a new principle in a device having that type of human utility covered by the patent laws. Thus the Fleming valve, which first used the hot frying pan of an incandescent filament to cause electrons to jump in a desired direction, and applied this principle to human communication, represented a basic patent in radio communications. The warping of the wings of the Wright aeroplane to maintain lateral stability was also held by the courts to be a basic patent, broad enough to cover the use of hinged flaps at the end of the wings. The "coverage" of a basic patent depends mainly on the wording of the claims in the patent specification filed by the inventor or his agent. When we consider the tremendous importance of these claims in patent litigation it is not surprising that in them we find some of the most astonishingly involved examples of legal and technical phraseology in the English language.

This matter of the number and wording of claims in patent specifications has a direct bearing on basic patents in plants, because the Patent Office has adopted a policy of allowing only a single claim to cover each patented plant. Thus the patented plant is claimed as a unit, not as a collection of more or less integrated parts as are many mechanical inventions. In adopting this principle with regard to plant patents the Patent Office has evidently followed the reasoning used with regard to patents granted to protect designs. These "design patents" are classified in a separate category by the Patent Office, and a separate law applies to them. In design patents only a single claim, in a prescribed form, ("the ornamental design for [an automobile radiator cap, etc.], as shown") is allowed.* The elements of the design, curves and straight lines, etc., are evidently considered to be the common property of the human race, as we might consider the genes of cultivated plants. "Basic" design patents apparently are not recognized by the courts.

In plant patents the Patent Office has held that a single claim, somewhat resembling the design patent claim, is the form to be followed. The form of the claim is not as specifically prescribed as in the case of design patents. In fact a rather surprising heterodoxy as to what to claim is to be noted. Thus some of the patentees claim the plant. Others claim not the plant but the flower or fruit as their unique and patentable contribution.† In mechanical patents the wording of the claim is vitally important in determining the extent of a basic patent. In the case of plants a different set of concepts is evidently thought to be operative. Thus when we compare the claims of Plant Patent 1 ("A climbing rose, as herein shown and described, characterized by its everblooming habit"), with the claim in Plant Patent 10 ("The climbing rose herein shown and described, characterized by its ever-blooming habit"), it is obvious that the only difference between the two roses, as far as the claim is concerned, is in the spelling of everblooming. In mechanical patents it would appear that the hyphen

*Where a detailed description is embodied in the specification, the wording—"as shown and described" is used, bringing the situation closer to that in plant patents.

†A few sample plant patent claims (italics author's, to emphasize variety of objects): "The *carnation* as shown and described, characterized particularly by its white blossom slightly flecked with pink . . ." (Plant Patent 3); "The *peach tree* herein described, characterized by the lateness of the ripening period of the fruit, as shown," (Plant Patent 7); "The *variety* of freesia herein described and shown, characterized particularly by its large size, . . ." (Plant Patent 17); "A *rose* substantially as shown and described, . . ." (Plant Patent 23); "A strawberry *plant*, as described, bearing fruit characterized . . ." (Plant Patent 60); "A *single chrysanthemum plant* as herein shown and described . . ." (Plant Patent 76); "The *new and distinct variety* of rose plant . . ." (Plant Patent 172); "The *nectarine* herein described characterized by . . ." (Plant Patent 173).

had been the only novel feature patented by the holder of Plant Patent 10. Since we are not aware that any question has been raised that Plant Patent 10 might represent an infringement on Plant Patent 1, it is clear that the definition of plant patents in general, and basic plant patents in particular, is very much in the formative stage at the present time. As a matter of fact the two roses in question are of different colors, though one could never deduce this from the claims.

The claim of the patent of the super-double nasturtium (Plant Patent 141) is worded as follows: "I claim: The variety or genetic type of nasturtium (*Tropaeolum majus*) herein described and illustrated, characterized particularly by its vigorous, stocky vegetative growth, and the unusually large size and complete doubleness of flowers." Color is not mentioned—vigor, large size, and complete doubleness are the only characteristics mentioned in the claim. A complete range of colors is mentioned in the descriptive portion of the patent application, but it would seem questionable how many colors can be included in a single variety. Most varieties of flowering plants are limited to a single color, so that including "all colors known to occur" in a species seems a rather broad and perhaps unwarranted extension of the plant patent concept. The patent law says that (with certain reservations) patents shall be granted for "any distinct and new variety of plant". That a plant patent specifically granting protection according to the wording of the law, for "any distinct and new variety" of plant is capable of being extended to cover an entire class of morphological types in a given species seems distinctly questionable. The wording of the law on this point is significant. A plant patent may be issued to one who has "invented or discovered and asexually reproduced any *distinct* and *new variety* of plant". Apparently it is held that Plant Patent 141 grants patent protection to a "genetic type", which is an entirely different concept from the concept of horticultural varieties. The law says nothing about "genetic types". The extension of patent protection to include "genetic types" is an interesting departure that may exceed the intention of Congress. Furthermore the meaning of the term is not clearly defined in the text of this patent. A gene for doubleness might conceivably be granted a "chemical patent" under the old patent laws (assuming that a gene is a chemical catalyst) but its patentability under the plant patent amendment would seem hardly feasible. If it is held that a plant patent covers only the asexually reproduced progeny of a given plant it is obvious that the claim in Plant Patent 141 is of very questionable validity. Since it applies to no particular variety, we may well speculate whether any patent protection could be claimed under the patent. The question is of great practical importance, and a court test to clarify the law would seem to be desirable.

In earlier articles in the JOURNAL* attention was called to the fact that two possible views might be held with regard to what a plant patent covers. One possible concept is that variety descriptions might be placed on a more or less mythical verbal basis, and that any plant approaching this description with a certain closeness would infringe on the patent. The alternative concept held that a patent extended protection only to the asexual progeny of a given plant. It was suggested that this latter alternative seemed to offer the only workable possibility with regard to plants. (This, again, was only a personal view, which had no court sanction behind it.) The possibility of obtaining basic plant patents would depend primarily on which view of the patent situation the courts chose to uphold. If, as is suggested by the design type of claim allowed by the Patent Office, the inventor is only entitled to protection

* ALLYN, ROBERT STARR. Plant Patent Queries. *Jour. Hered.* 24: 55-58. 1933. COOK, ROBERT C. Other Plant Patents. *Jour. Hered.* 24-49-54. 1933. The Commissioner Replies" *Jour. Hered.* 24:163-164.

on the asexual progeny of a given plant, basic plant patents would appear to be impractical. If, on the other hand, we are dealing not with a biological entity but with a large collection of more or less distinct elements, the "basic plant patent" idea may be theoretically possible. In practice the complexities of attempting to administer the plant patent law in this manner become so great that the possibility of developing along such lines a workable system of plant protection seems very doubtful.

The practical implications of this distinction are perhaps suggested by the advertising in the 1936 *Burpee Annual* of "Miracle Mixture" Nasturtium Seed. This seed is produced by pollinating double Nasturtiums with super-double pollen. As a result "seed of Burpee Miracle Mixture will produce various types of flowers, some will be double like Golden Gleam and others will be Super Double. Burpee Super Double Nasturtium plants, *and those grown from the Miracle Mixture Seed* are protected by Plant Patent 141" (Italics ours.) Since no assurance is given as to the number or color of the "patented plants" that will be obtained in Miracle Mixture, a situation unique in patent law would exist should such a "pig-in-a-poke" sale of patented objects be upheld by the courts.

Doubleness is rather a variable characteristic. If other new varieties of "Super-Double" Nasturtiums were developed that were "distinctly new and different" from that (those?) described in Plant Patent 141, it would seem to the writer that a patent on such varieties could be obtained. This is especially likely if the origin of this second Super-double could be proved to be independent of the origin of the Burpee Super-Double. Thus, if a mutation were to arise (as a result of X-radiation, possibly) that had double flowers with fringed petals and a violet fragrance, the newness and the distinctness would seem to be much greater than that setting apart existing varieties. It is hard to imagine that a patent would not be granted in such a case. Even if the Burpee "genetic type" (doubleness gene?) were combined in some way to produce a "new and distinct variety" the law would appear to make it mandatory for the Patent Office to issue a patent.

EDITOR.

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When Two Seem to Be a Crowd

Some thoughts on the number of Robert C. Cooks who may sling printer's ink without spoiling the Broth of Publication

Having received several inquiries from his friends, the Robert C. Cook who edits the JOURNAL OF HEREDITY takes this occasion to disclaim any connection, genetic or economic, with the Robert C. Cook Publishing Company of New York City. That organization publishes among other things an *Educational Who's Who.* Apparently several of my friends have recently filled in a questionnaire emanating from that publishing house under the impression that they were performing a labor of love for the "HEREDITY" Robert C. Cook. In view of this situation the labor was wasted as far as love of genetics was concerned, though the spirit in which it was done is greatly appreciated by the member of this pair of nomenclatorial identical twins who edits THE JOURNAL OF HEREDITY.

"HEREDITY" LANTERN SLIDES

MAN

16-397. Gregor Mendel's Handwriting — First Page of "Studies of Plant Hybrids".
17-435. Merton House—Home of William Bateson.
21-1-Cover. The "Fuchsia-Picture" of Mendel.
21-No. 2-Cover. Francis Galton.
26-158. Ishmael Family—Six Generations of a Degenerate Family.
26-159. Roosevelt Family—Pedigree Chart of a Superior Family.
26-292. Dr. and Mrs. Hugo de Vries.
15-330. Fused Finger Joints.
17-393. Short Legs—Inherited Achondroplasia.
20-75. Extra Fingers—Recessive Polydactylism.
20-74. Chart Showing Inheritance of Polydactylism.
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22-47. Palm Prints of Fraternal Twins.
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23-6. Identical Twins (Mary and Mabel) at Two Years—Reared Apart.
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24-444. Table Classifying Handedness in Twins.
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